



# Scientific Inventory of Onshore Federal Lands' Oil and Gas Resources and Reserves and the Extent and Nature of Restrictions or Impediments to their Development

**The Paradox/San Juan, Uinta/Piceance,  
Greater Green River, and Powder River Basins  
and the Montana Thrust Belt**

**In Compliance with the Energy Policy and Conservation Act  
Amendments of 2000, P.L. 106-469 §604**

Prepared  
by the  
United States  
Departments  
of the  
Interior,  
Agriculture,  
and Energy



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*Prepared by the*

U.S. Departments of the Interior, Agriculture and Energy



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## EXECUTIVE SUMMARY

### THE MANDATE FROM CONGRESS

In November 2000, Congress passed and President Clinton signed the Energy Policy and Conservation Act Amendments of 2000 (EPCA) which directed the Secretary of the Interior, in consultation with the Secretaries of Agriculture and Energy, to conduct an inventory of oil and natural gas resources beneath Federal lands.

“The inventory shall identify: 1) the United States Geological Survey reserve estimates of oil and gas resources underlying these lands; and 2) the extent and nature of any restrictions or impediments to the development of such resources.”

This act marks the first time that Congress asked the Department to conduct a study of restrictions.

On October 11, 2001, Congress provided its sense of priority for this study:

“...In light of recent attacks on the United States that have underscored the potential for disruptions to America’s energy supply, the managers believe this project should be considered a top priority for the Department.”

This report is a portion of the inventory of public oil and gas resources requested by Congress. This inventory is a comprehensive review of federal oil and gas resources and constraints on their development in five basins in the Interior West (Figure ES-1). These basins contain most of the onshore natural gas and much of the oil under Federal ownership within the 48 contiguous states. The EPCA requires that all onshore Federal lands be inventoried. The inventory will be expanded to include additional Federal lands and resources in the future.

For the federal public-land managing agencies, principally the Department of the Interior’s Bureau of Land Management (BLM) and the Department of Agriculture’s Forest Service (USFS) and the citizens they serve, this inventory will serve primarily as a planning tool. It provides public-land managers with additional information to help them develop management plans for the lands under their jurisdiction. It allows them to identify areas of high oil or gas potential and to evaluate the effectiveness of available stipulations in balancing the responsible development of those resources with the protection of other valuable resources in the area. Conversely, it also allows resource managers to identify areas of low oil and gas potential but high potential for other resources (e.g. wildlife) or uses (e.g. recreation). In these situations, resource managers and the public can consider applying land management strategies that may promote increased protection of valuable resources or promotion of uses that might ordinarily conflict with oil or gas development. This report is a critical step in evaluating whether existing rules are appropriate, or need to be changed, either to provide greater protection to the environment or to promote appropriate resource development.

## THE PRESIDENT'S NATIONAL ENERGY POLICY DIRECTIVES

In May 2001, President Bush's National Energy Policy directed that the EPCA inventory be expedited and that constraints to federal oil and gas leasing be reassessed and modified "where opportunities exist (consistent with the law, good environmental practice, and balanced use of other resources)." The National Energy Policy further directed that any reassessment of constraints be conducted "with full public consultation, especially with people in the region." This inventory provides information regarding the geographical relationship between oil and gas resources and reserves and the constraints that govern their development. It is not a reassessment of any stipulations on the development of oil and gas resources. The public's opportunity to participate in any reassessment of restrictions on oil and gas activities will occur in public-land planning or legislative processes. This inventory provides some basic information for any such processes. Additional information may be available from monitoring and scientific studies incorporated into adaptive management processes.

The National Energy Policy provides an overview of the U.S. energy situation and alternatives available to increase energy efficiency and conservation, increase energy supplies, and protect the environment. At the direction of Congress, the present study focuses on the traditional energy resources of oil and natural gas beneath Federal lands\*.

This inventory was prepared by staff of the Department of the Interior's BLM and United States Geological Survey (USGS); the USFS; the Department of Energy (DOE); and the Energy Information Agency (EIA). The USGS provided the assessment of undiscovered, technically recoverable oil and natural gas resources beneath Federal lands based on commercially available data. The EIA contributed the analysis of proved reserves for Federal lands. The EIA data incorporates economic considerations not included in the USGS resource assessment. The DOE provided technical expertise to guide the design and analysis process for the inventory. The BLM and the USFS contributed their land-use planning information regarding oil and natural gas availability and leasing stipulations for the lands under their respective jurisdictions.

## METHODOLOGY

This inventory is based on information that has been previously developed through both the scientific and planning processes of the contributing federal agencies. This information has often been provided to the public for its review and use. The information used in the present study is the best commercial and scientific information available. It has been compiled and analyzed by experts from the contributing agencies. The analytical methods and protocols used in the supporting studies have been subjected to rigorous review. The present study necessarily incorporates the assumptions, conditions, and limitations of the supporting scientific information as discussed in this report. This inventory is significant because for the first time information about oil and gas resources and reserves is overlain in a comprehensive manner with information about constraints on their recovery.

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\* In recognition of the increased emphasis on the development of alternative energy resources in the National Energy Policy, the Department of Energy, in coordination with the Department of the Interior, is releasing a report, analogous to the present report, on the potential of particular federal lands to support alternative energy technologies such as wind, solar and biomass.

## Executive Summary

A steering committee of the participating agencies identified five major geologic basins within the Interior West as priority geographic areas to inventory. The five basins are the Paradox/San Juan Basins in Colorado, Utah and New Mexico; the Uinta/Piceance Basins in Colorado and Utah; the Greater Green River Basin in Wyoming, Colorado and Utah; the Powder River Basin in Montana and Wyoming; and the Montana Thrust Belt in Montana.

These basins were selected for the inventory for several reasons. First, these basins encompass nearly 104 million acres. About 59 million acres in this area are under federal management. This acreage includes split estate lands in which private surface lands are underlain by federal subsurface mineral rights. Second, these basins contain most of the onshore natural gas and much of the oil under public ownership within the 48 contiguous states. Third, the population of the Interior West is growing rapidly. Public lands in this region face increased demands for their use as sites for recreation, livestock grazing, forestry, open space, wildlife habitat, mining, and oil and gas production.

The analysis of constraints to development centered on two factors that affect access to oil and gas resources on Federal lands. Those factors are (1) whether the lands are "open" or "closed" to leasing, and (2) the degree of access afforded by lease stipulations on "open" lands. All oil and gas leases have statutory and regulatory requirements. These stipulations can have many purposes ranging from the protection of environmental, social, historical, or cultural resources or values to the payment of rentals and royalties.

Approximately 1,000 different lease stipulations are being applied by the land managing agencies in the five basins studied. To focus the analysis of constraints on oil and gas development, the inventory evaluated the extent of public lands (1) in which leasing is permitted under standard stipulations, and (2) in which leasing is permitted with increasing limitations on access, principally seasonal occupancy restrictions, and (3) in which oil and gas leasing is prohibited. The analysis also included consideration of exceptions to stipulations granted after a review of on-the-ground conditions and the use of modern technologies such as directional drilling. The ten categories of restrictions analyzed in this report include the complete range of access restrictions associated with oil and gas leasing in the five basins.

## CONCLUSIONS

While the results of this analysis are different for each of the five basins studied, the cumulative results for all of the basins (Figure ES-2) can be summarized as follows (Federal lands, including split estate, in the five basins total 59,416,000 acres).

1. Approximately 39 percent (23,091,000 acres) of the Federal land in these basins is available for oil and gas leasing with standard stipulations (Figure ES-2, "Leasing, Standard Lease Terms"). Based on resource estimates, these lands contain 57 percent of the technically recoverable oil and 63 percent of the technically recoverable gas in the basins.
2. Approximately 25 percent (15,152,000 acres) of the Federal land is available for leasing with restrictions on oil and gas operations beyond standard stipulations (Figure ES-2, All other "Leasing" categories except "Leasing, Standard Lease Terms"). Based

on resource estimates, these lands contain 28 percent of the technically recoverable oil and 25 percent of the technically recoverable gas in the basins.

3. Approximately 36 percent (21,173,000 acres) of the Federal land in the five basins is not available for leasing (Figure ES-2, 3 “No Leasing” categories). Based on resource estimates, these lands contain about 15 percent of the technically recoverable oil and 12 percent of the technically recoverable natural gas in the basins.

## COMPLIANCE WITH THE LAW

All oil and gas leases on Federal land, even those with the least restrictive stipulations, are subject to full compliance with all substantive and procedural environmental laws and regulations. These laws include the National Environmental Policy Act, Clean Water Act, Clean Air Act, Endangered Species Act, and the National Historic Preservation Act. While compliance with these laws may delay, modify, or prohibit oil and gas activities, these laws represent the values and bounds Congress believed appropriate to place on Federal land managers for their stewardship of Federal lands. The present study was conducted at the request of Congress to provide information for it to consider in forthcoming deliberations on the role of Federal lands in the U.S. energy situation.

It is important to emphasize that this inventory was prepared at the direction of Congress. It is not a decisionmaking document. The inventory identifies areas of high and low oil and gas potential and the nature of constraints to the development of those resources in five basins in the Interior West. Any reassessment of these restrictions on oil and gas activities will occur in public-land use planning or the legislative process, both of which are fully open to public participation and debate over the appropriate balance between resource protection and resource development.

## Executive Summary

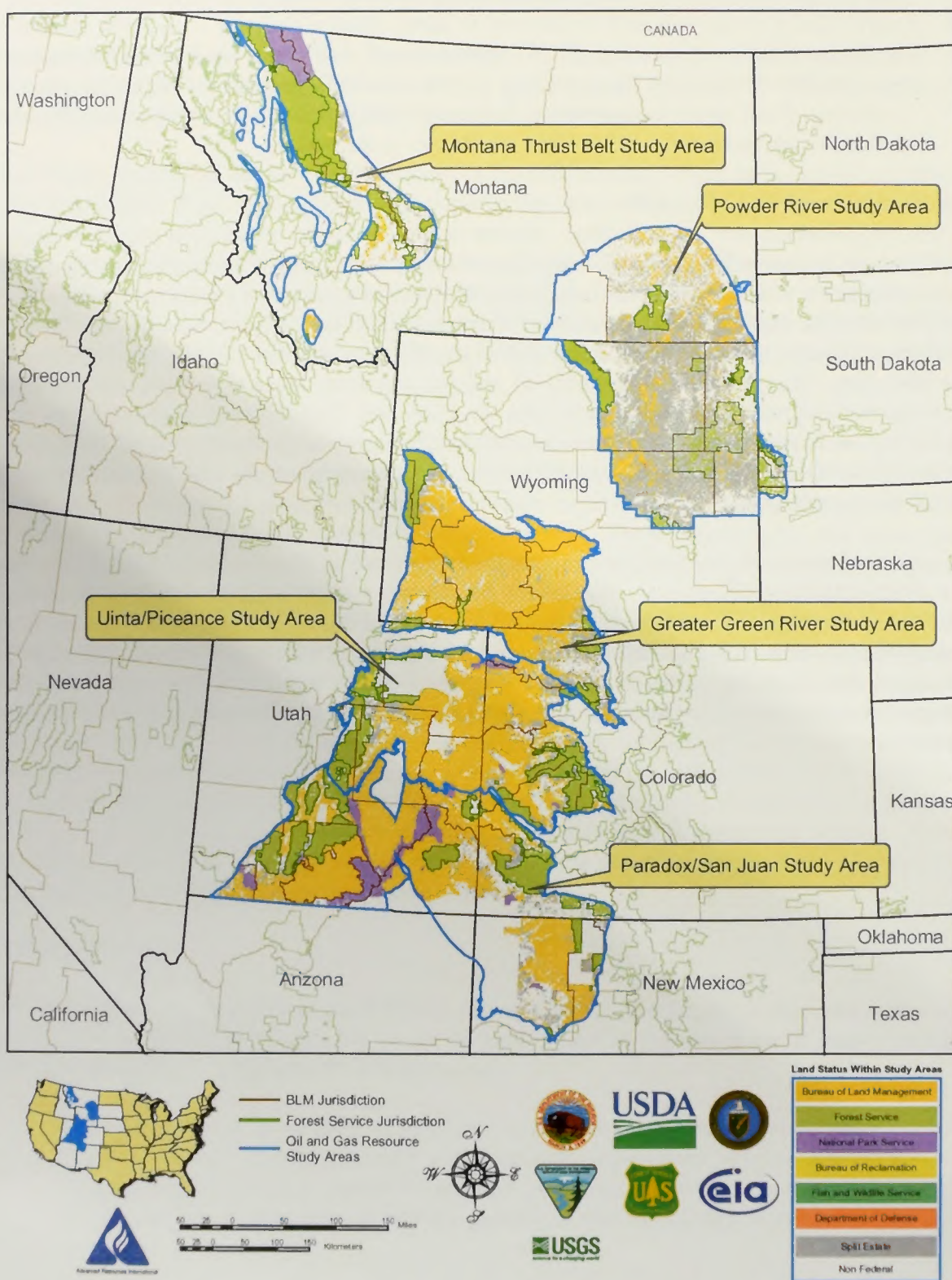


Figure ES-1 Outline of Study Areas Showing Federal Land Status

	Access Category	Area		Resources		
		(acres x1000)	Percent of Federal	Total Liquids* (MMBbl)***	Percent of Federal	Total Natural Gas** (Bcf)****
1.	No Leasing (Statutory/Executive Order), (NLS)	10,068	16.9%	298	7.7%	9,035
2.	No Leasing (Administrative), (NLA/LUP)	6,007	10.1%	116	3.0%	3,690
3.	No Leasing (Administrative), (NLA)	5,098	8.6%	182	4.7%	3,185
4.	Leasing, No Surface Occupancy (NSO)	2,714	4.6%	50	1.3%	3,120
5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months (TLs >9)	25	0.0%	3	0.1%	114
6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months (TLs 6-9)	2,521	4.2%	250	6.5%	5,549
7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months (TLs 3-6)	5,442	9.2%	528	13.7%	20,401
8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months (TLs <3)	697	1.2%	8	0.2%	733
9.	Leasing, Controlled Surface Use (CSU)	3,753	6.3%	221	5.7%	6,080
10.	Leasing, Standard Lease Terms (SLTs)	23,091	38.9%	2,198	57.0%	86,566
Total, Federal Lands Including Split Estate		59,416	100.0%	3,854	100.0%	138,472
Total Non-Federal		44,256		2,455		87,668
Total Study Area		103,672		6,309		226,141

\* Comprising oil, NGLs and liquids associated with natural gas reservoirs

\*\* Comprising associated dissolved and nonassociated natural gas

\*\*\*MMBbl -- Millions of Barrels

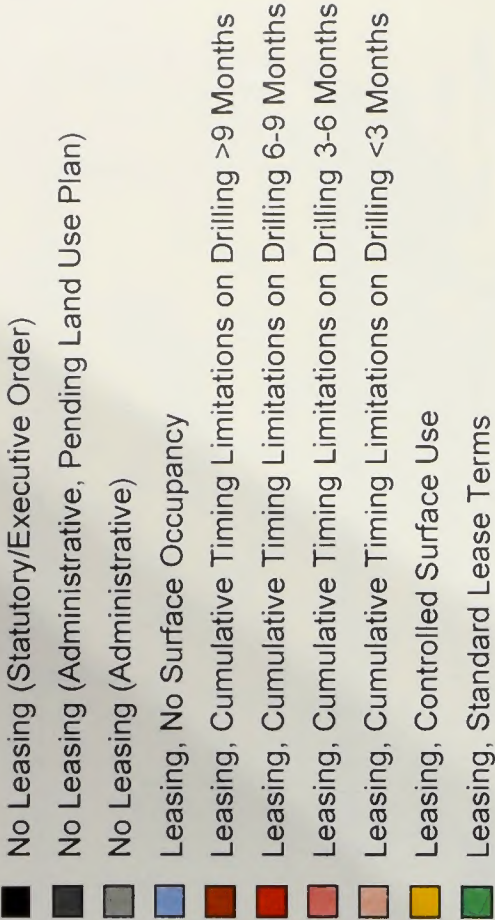
\*\*\*\*Bcf -- Billion cubic feet

Small rounding errors  
may be present

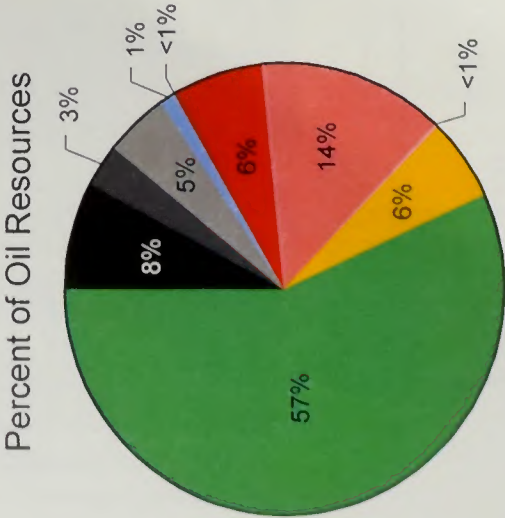
Table ES-1 Summary of All EPCA Inventory Areas – Oil and Natural Gas Resources Affected by Access Categories

More  
Constrained  
▲Less  
Constrained  
▼

Percent of Federal and Split Estate Lands



Percent of Oil Resources



Percent of Natural Gas Resources

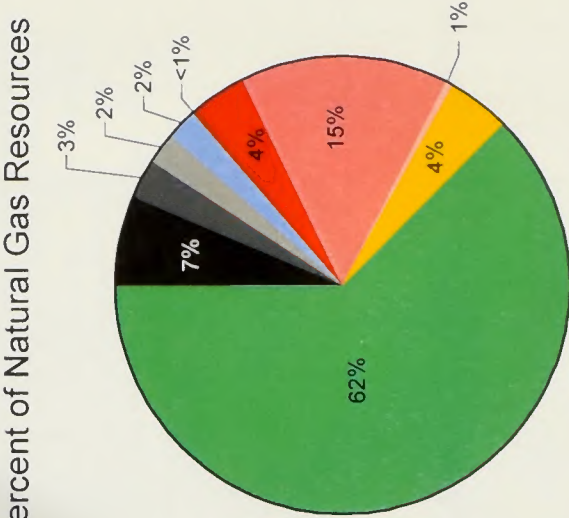


Figure ES-2 Summary of All EPCA Inventory Areas – Oil and Natural Gas Resources Affected by Access Categories

## 1.0 INTRODUCTION

As the energy needs of the Nation continue to grow, the sedimentary basins in the Interior West have been identified as a significant future supply source to help meet these needs, especially for natural gas. The United States currently uses about 23 trillion cubic feet (Tcf) of natural gas annually. The U.S. produces approximately 19 Tcf of its annual natural gas demand and imports the remaining 4 Tcf. The EIA of the DOE in its *Energy Outlook 2003* reference case projects that the demand for natural gas will rise to just under 35 Tcf by 2025. The Minerals Management Service (MMS) estimated in 2000 that approximately 58 percent of our country's undiscovered natural gas resources (over 362 Tcf) lie under the Outer Continental Shelf. However, production in the shallow water areas of the Gulf of Mexico has been steadily declining – some 13 percent from 1997 through 1999. The study presented here estimates that there are 138 Tcf of natural gas resources and reserves on Federal lands in the Interior West, making it the second largest natural gas resource in the United States after the Outer Continental Shelf. This 138 Tcf is sufficient to heat all of the 55 million homes that use natural gas in the United States for 39 years.

At the same time, the Interior West is one where multiple use interests and attendant environmental issues often intersect. Multiple uses of the Federal lands in this region, which include but are not limited to grazing, forestry, recreation, wildlife habitat, open space, wilderness, rights-of-way, and minerals exploration and production often conflict with each other. The population of the region is growing rapidly, and approximately 22 million people live within 25 miles of Federal lands. Recognizing this situation, Congress directed that quantitative assessments of the Nation's Federal onshore oil and gas resources be analyzed in relation to Federal actions that inhibit access to these resources in order to add clarity to the debate and assist energy policymakers and Federal land managers in making decisions concerning oil and gas resource development.

The studies reported here were conducted to address these needs for a part of the Interior West (figure 1a), comprising the Paradox/San Juan, Uinta/Piceance, Greater Green River, and Powder River basins and the Montana Thrust Belt. About 59 million acres of Federal lands (including split estate) present among the almost 104 million acres in these study areas, were analyzed.

A full set of acronyms used in this report, as well as a glossary, can be found in Appendices 1 and 2, respectively.

### 1.1 BACKGROUND

Access to Federal lands is probably the most oft-cited issue affecting oil and gas production in the Interior West. The restrictions and leasing stipulations that constrain access to Federal lands in the region are a complicated patchwork of requirements that increase costs and delay activity. They range from areas unavailable for leasing, to areas where the minerals can be leased but the surface of the land may not be occupied in order to recover those resources. There are also limitations on drilling activities due to a variety of environmental considerations.

## Section 1

### Introduction

Recent attempts to understand the impacts of Federal land management decisions on access to oil and gas resources began with a 1999 National Petroleum Council (NPC) study. In its report<sup>1</sup> on natural gas, the NPC (an advisory committee to the Secretary of Energy) forecast that U.S. demand for natural gas would grow to 29 Tcf in 2010 and would exceed 31 Tcf in 2015.

One of the objectives of the NPC study was to collect and analyze data on land use and natural gas resources for Federal lands in the Interior West to identify opportunities for increasing natural gas supply from this area. The NPC identified the Interior West as a significant future source of gas supply to help meet the anticipated growing demand. However, the NPC also estimated that about 40 percent (137 Tcf) of the potential supply from this region is currently unavailable for leasing or is subject to surface-use access restrictions because of competing uses or environmental considerations. This analysis was based on a limited sample of Federal lands in the region. The NPC report was the first assessment of access constraints associated with Federal land use designations and related environmental stipulations in the Interior West. The report was developed through a cooperative effort of Federal agencies, including the DOE, the BLM, and the U.S. Department of Agriculture-Forest Service (USDA-FS) and industry. Representatives from State and local governments and other stakeholders also participated.

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<sup>1</sup> Meeting the Challenges of the Nation's Growing Natural Gas Demand, December 1999, available on the NPC website: <http://www.npc.org/reports/ng.html>.

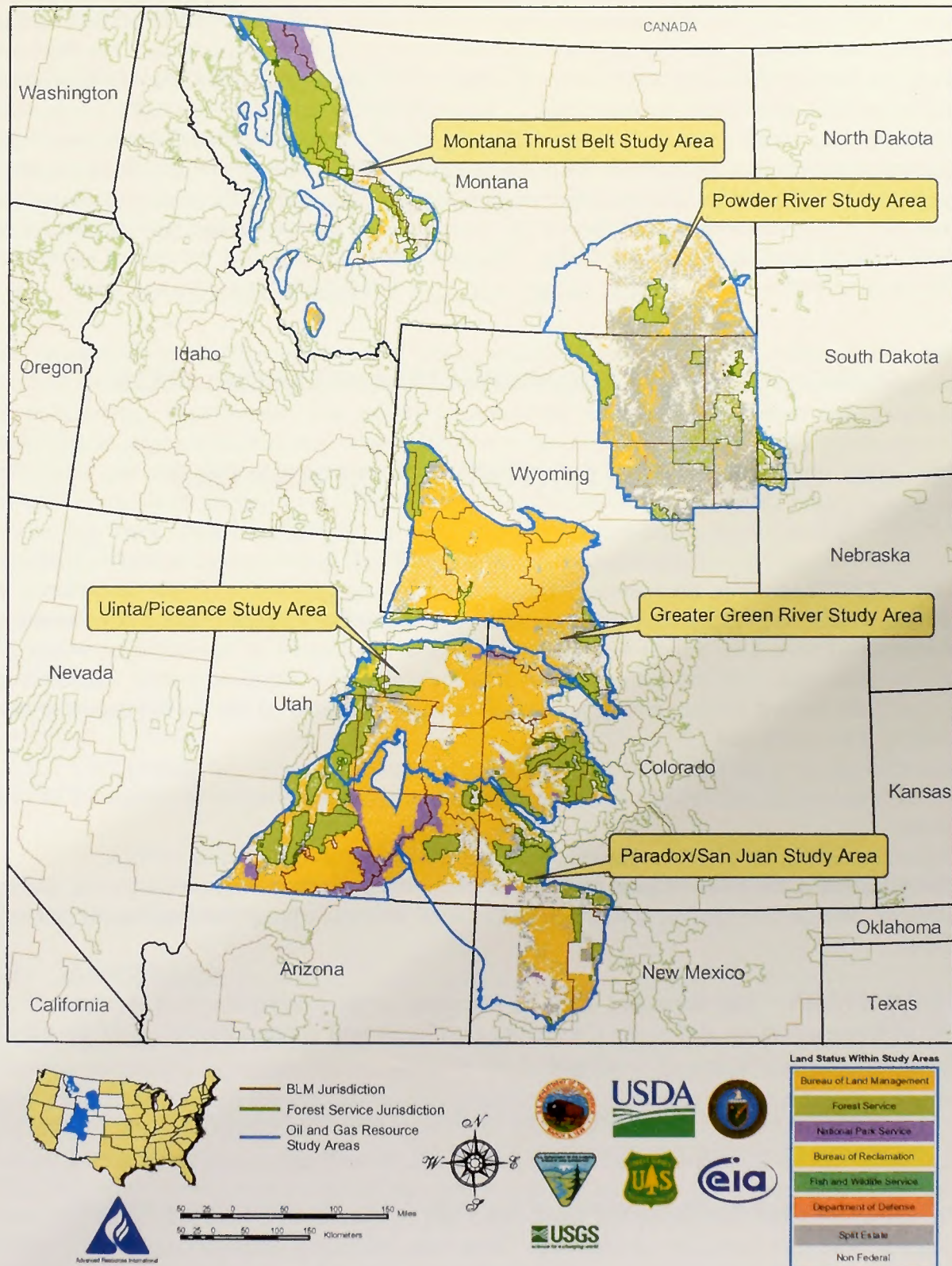


Figure 1a Outline of Study Areas Showing Federal Lands

In response to the NPC recommendation, DOE, with the cooperation of the Department of the Interior (DOI) and the U.S. Department of Agriculture (USDA), embarked on an effort to assess the relationship between gas resources and land use restrictions on Federal lands. The first area studied was the Greater Green River Basin (GGRB) of Wyoming and Colorado. DOE released its report on this assessment in June 2001<sup>2</sup>. Both the NPC study and the GGRB study were substantially less comprehensive than this study and report. While the GGRB study was being conducted, Congress reauthorized the EPCA in November 2000. Section 604 of this law required a similar study, to be led by DOI in cooperation with the USDA and DOE, which was to include an analysis of undiscovered oil and natural gas resources and proved oil and gas reserves for all onshore Federal lands in the United States. The text of Section 604 and the related conference report are given below.

## 1.2 ENERGY POLICY AND CONSERVATION ACT LEGISLATION

### SEC. 604. SCIENTIFIC INVENTORY OF OIL AND GAS RESERVES

**(a) IN GENERAL**--The Secretary of the Interior, in consultation with the Secretaries of Agriculture and Energy, shall conduct an inventory of all onshore Federal lands. The inventory shall identify--

(1) the United States Geological Survey reserve estimates of the oil and gas resources underlying these lands; and

(2) the extent and nature of any restrictions or impediments to the development of such resources.

**(b) REGULAR UPDATE** --Once completed, the USGS reserve estimates and the surface availability data as provided in subsection (a)(2) shall be regularly updated and made publicly available.

**(c) INVENTORY** --The inventory shall be provided to the Committee on Resources of the House of Representatives and to the Committee on Energy and Natural Resources of the Senate within two years after the date of enactment of this section.

**(d) AUTHORIZATION OF APPROPRIATIONS** --There are authorized to be appropriated such sums as may be necessary to implement this section<sup>3</sup>.

*Congress further emphasized the urgency of this study during the appropriation process:*

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<sup>2</sup> "Federal Lands Analysis, Natural Gas Assessment, Southern Wyoming and Northwestern Colorado, Study Methodology and Results," June 2001, available on the DOE website:  
[http://fossil.energy.gov/techline/tl\\_ggrb\\_gas.shtml](http://fossil.energy.gov/techline/tl_ggrb_gas.shtml).

<sup>3</sup> Energy Policy and Conservation Act Amendments of 2000, P.L. 106-469, § 604, November 9, 2000.

CONFERENCE REPORT ON H.R. 2217, DEPARTMENT OF INTERIOR AND RELATED  
AGENCIES APPROPRIATIONS ACT, 2002

JOINT EXPLANATORY STATEMENT OF THE COMMITTEE OF CONFERENCE

The managers agree to the following:

...In light of recent attacks on the United States that have underscored the potential for disruptions to America's energy supply, the managers believe this project should be considered a top priority for the Department<sup>4</sup>.

### 1.3 THE NATIONAL ENERGY POLICY, MAY 2001

The President's comprehensive National Energy Policy, issued May 2001, outlined more than a hundred recommendations to diversify and increase energy supplies, encourage conservation and improve energy distribution. The policy recommends a balanced approach that emphasizes renewable energy production and conservation as well as traditional fossil fuel production. Oil and natural gas was a major component of the President's policy, in particular, examining ways to increase access to these resources. The Policy noted that some Federal lands, otherwise available for leasing have been legislatively or administratively withdrawn from leasing. The Vice-President's National Energy Policy Development Group recommended:

"...that the President direct the Secretary of the Interior to examine land status and lease stipulation impediments to Federal oil and gas leasing, and review and modify those where opportunities exist (consistent with the law, good environmental practice, and balanced use of other resources).

Expedite the ongoing Energy Policy and Conservation Act study of impediments to federal oil and gas exploration and development, and

Review public lands withdrawals and lease stipulations, with full public consultation, especially with the people in the region, to consider modifications where appropriate<sup>5</sup>."

### 1.4 APPROACH

A Steering Committee of senior staff from the participating agencies was formed to develop an effective process to complete the inventory. The Steering Committee identified five major geographic areas that had the greatest oil and natural gas development potential for analysis in the inventory. The five areas are the Paradox/San Juan Basins, the Uinta/Piceance Basins, the Greater Green River Basin, the Powder River Basin, and the Montana Thrust Belt (figure 1a). These five study areas contain most of the natural gas and much of the oil resource under public ownership in the onshore United States. The study areas are defined by the aggregation of the USGS oil and gas resource plays for each area. The energy resource and land status and stipulation data for these areas have been incorporated into a Geographic Information System (GIS) that allows derivative mapping and statistical analysis.

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<sup>4</sup> Congressional Record, October 11, 2001, House, p. H6526.

<sup>5</sup> National Energy Policy, Report of the National Energy Policy Development Group, May 2001.

## 1.5 ROLES OF THE AGENCIES

The EPCA designated the Departments of Interior, Agriculture, and Energy as responsible for the inventory. The Steering Committee provided guidance for conducting the studies, decisions concerning critical parameters, a review of the methodology developed by the one of the firms contracted for the inventory<sup>6</sup>, and a review of the results.

The Secretary of the Interior designated the BLM to be the lead agency for the EPCA inventory. The BLM maintains the oil and gas lease stipulation information for lands under its jurisdiction, as well as land status data for all Federally owned lands within the United States.

The USGS, also a bureau of the DOI, contributed its assessments of undiscovered, technically recoverable oil and natural gas. The primary source of the oil and gas resource information used in this study was the USGS National Assessment of Oil and Gas Resources.

The Secretary of Agriculture designated the USDA-FS, its primary land management agency, to contribute its information regarding oil and gas lease availability and leasing stipulations for lands within the National Forest System.

The DOE, as author of the above-mentioned GGRB report, contributed its expertise and experience in guiding the design and analysis process for the EPCA inventory. DOE's EIA contributed its analysis of proved reserves estimates for Federal lands.

During the course of this study, members of the EPCA Steering Committee and contract personnel visited field offices within the various basins. BLM and USDA-FS personnel from over 70 offices (table 1a) participated in these visits. The purpose of these visits was to inform BLM and USDA-FS officials about the studies and to solicit input concerning lease stipulations and other issues of concern regarding oil and gas development. Data collection was performed during and following the field visits.

## 1.6 INTENDED USE

The EPCA inventory has been designed to be useful to a wide range of interests. In a broad sense, it gives a picture of where oil and gas is estimated to occur and an idea of what statutory and administrative constraints limit exploration and development. The EPCA inventory can be used by land management agencies to identify areas of high resource potential and then to examine land management decisions that affect access to those resources on Federal lands. Both the public and the land managers will have information about the magnitude of oil and natural gas losses due to access limitations which may be utilized in conjunction with other information about other resource values and the environment.

The highly detailed stipulation data, brought together here for the first time, can be used in conjunction with the resource data by Congress, industry, environmental organizations, and other interested parties for a variety of analyses. Land withdrawals and oil and gas lease stipulations are designed to protect or mitigate adverse impacts to other valuable land resources. Land management agencies can analyze this information together with existing policies and procedures

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<sup>6</sup> The principal firms contracted for the EPCA inventory were Advanced Resources International, Arlington, VA, and Premier Data Services, Denver, CO.

and look for opportunities to improve and enhance the decisions in their land use planning, leasing, and permitting processes. Agencies also can use this information to prioritize the need for additional data and analyses, and to identify where opportunities may exist for improving access to oil and gas resources. Overall, the EPCA inventory will provide additional information to help resolve development issues. It can help land management agencies to be more responsive to the needs of their customers.

The primary product of the EPCA inventory is a GIS database composed of many layers of geographic data referenced by longitude and latitude. An important caution applies to the use and interpretation of the undiscovered energy resources.

The caution is that the *precise* locations of undiscovered oil and natural gas resources are uncertain. Without extensive exploratory drilling, the assessment process is highly probabilistic. Therefore, specific assumptions were made concerning the undiscovered oil and natural gas resources within the inventory area. Over the last several decades, the USGS methodology has been the government's standard for oil and gas resource estimation. The assessment process is a peer-reviewed statistical process that takes into consideration all available information to gain an understanding of the petroleum geology of the provinces being assessed. The USGS geologists using this information define the number of potential oil and gas plays within the provinces. The geologist then develops a probability distribution, which estimates the likelihood that a certain number and size of oil and natural gas accumulations are present within the province. There is additional uncertainty regarding the likelihood that a certain volume of oil and natural gas within each play is present. Therefore, for the purpose of the EPCA inventory it was assumed that there was a uniform distribution of the resources within a given play. It is important to note that for these reasons, the EPCA analysis does not imply that the locations of accumulations of undiscovered oil and natural gas resources are known to occur under specific land parcels.

## 1.7 PRODUCTS/FUTURE DIRECTION

The tables, data, maps (GIS products), and this summary report, which describes the methodology, applied standards, results, and land access issues, are available on CD-ROM and from the DOI (<http://www.doi.gov>) or BLM website (<http://www.blm.gov/>).

EPCA Section 604 requires that all Federal lands of the onshore United States be inventoried. The Steering Committee anticipates that the EPCA inventory will be expanded in the future to additional areas where Federal lands overlie undiscovered resources, ultimate recovery appreciation (reserves growth), and proved oil and gas reserves. The information and analysis for already-studied areas will be updated as sufficient new information warrants.

Section 1  
Introduction

Paradox/San Juan Study Area	Greater Green River Study Area
Albuquerque, NM BLM Field Office	Ashley NF
Ashley NF	BLM Wyoming State Office
Bureau of Reclamation	Bridger-Teton NF
Carson NF	Bureau of Reclamation
Cedar City, UT BLM Field Office	Fishlake NF
Cibola NF	Kemmerer, WY BLM Field Office
Dixie NF	Lander, WY BLM Field Office
Durango, CO BLM Field Office	Little Snake, CO BLM Field Office
Farmington, NM BLM Field Office	Medicine Bow-Routt NF
Fishlake NF	Pinedale, WY BLM Field Office
Grand Junction BLM Field Office	Rawlins, WY BLM Field Office
Grand Mesa/Uncompahgre/Gunnison NF	Rock Springs, WY BLM Field Office
Grand Staircase-Escalante National Monument	
Kanab, UT BLM Field Office	Powder River Study Area
Manti-La Sal NF	Big Horn NF
Moab, UT BLM Field Office	Billings, MT BLM Field Office
Monticello, UT BLM Field Office	BLM Montana State Office
Price, UT BLM Field Office	BLM Wyoming State Office
Richfield, UT BLM Field Office	Black Hills NF
Rio Grande NF	Buffalo Gap National Grasslands
San Juan NF	Buffalo, WY BLM Field Office
Santa Fe NF	Casper, WY BLM Field Office
St. George, UT BLM Field Office	Custer NF
Uncompahgre, CO BLM Field Office	Miles City, MT BLM Field Office
	Nebraska NF
Uinta/Piceance Study Area	Newcastle, WY BLM Field Office
Ashley NF	Oglala National Grasslands
BLM Utah State Office	South Dakota BLM Field Office
Bureau of Reclamation	Thunder Basin National Grasslands
Fishlake NF	
Glenwood Springs, CO BLM Field Office	Montana Thrust Belt Study Area
Grand Junction, CO BLM Field Office	Beaverhead-Deerlodge NF
Grand Mesa/Uncompahgre/Gunnison NF	Bitterroot NF
Gunnison, CO BLM Field Office	BLM Montana State Office
Little Snake, CO BLM Field Office	Bureau of Reclamation
Manti-La Sal NF	Butte, MT BLM Field Office
Medicine Bow-Routt NF	Dillon, MT BLM Field Office
Moab, UT BLM Field Office	Flathead NF
Price, UT BLM Field Office	Gallatin NF
Richfield, UT BLM Field Office	Helena NF
Salt Lake, UT BLM Field Office	Kootenai NF
Uinta NF	Lewis and Clark NF
Uncompahgre, CO BLM Field Office	Lewistown, MT BLM Field Office
Vernal, UT BLM Field Office	Lolo NF
White River NF	Missoula, MT BLM Field Office
White River, CO BLM Field Office	

NF = National Forest

Table 1a

BLM and Forest Service Offices Contacted for the Inventory

## 2.0 METHODOLOGY

The Paradox/San Juan, Uinta/Piceance, Greater Green River, and Powder River basins, and the Montana Thrust Belt, compose the five study areas in this inventory. They were delineated by the aggregation of oil and/or natural gas resource plays<sup>1</sup> in these basins as defined by the USGS National Assessment of Oil and Gas Resources. Resource play boundaries and oil and gas resource estimates within the plays were obtained in GIS format from the USGS. These plays were aggregated in a GIS to create a resource density map layer for each study area.

Land status was compiled from the "Status" dataset from BLM's land records database to generate GIS maps for the analyses. Oil and gas leasing stipulation data were obtained for each jurisdiction from BLM Field Offices and USDA-FS Offices in the study areas. Most of the data were available in GIS format; some existed only as hardcopy and had to be digitized to create GIS digital map files.

Stipulations attached to oil and gas leases currently in effect are not maintained in an automated system and therefore some existing stipulations may not have been used in this inventory. The stipulations used are primarily those contained in the National Forest Plans and BLM Resource Management Plans in effect as of the date of this inventory (August 2002), and are those applied when new oil and gas leases are issued. To the extent that current leases were issued under, and are stipulated according to an existing land use plan, the inventory reflects an accurate situation. Older leases issued before the relevant plan's effective date may not be stipulated accordingly. To completely characterize stipulations on existing leases, an extensive manual file search would have to be performed. However, it is reasonably accurate to consider the plan stipulations as a proxy, because the environmental conditions that necessitate stipulations often are the driver for conditions of approval that are attached to drilling permits on older leases in order to achieve the needed environmental protection.

The analyses for the EPCA inventory entailed spatial intersection (in a GIS) of oil and gas resource information with data on land status and leasing stipulations. Because stipulations are conditions that are attached to oil and gas leases for environmental protection and other reasons, they are subject to change over time. This inventory represents a "snapshot in time" of the conditions present within the study areas. The inventory also takes into account how leasing stipulations are implemented in practice by Federal land managers by considering the effect of directional drilling and the frequency with which exceptions to the stipulations are granted.

Additional factors that affect oil and gas exploration and development on Federal lands generally cannot be quantified geographically prior to the receipt of a specific drilling application, nor are there requisite data available for quantitative analysis. These include:

- Protection for threatened and endangered species and surveys to determine whether a lease contains habitat for such species;

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<sup>1</sup> A play is a set of known or postulated oil and gas accumulations sharing similar geologic, geographic, or temporal properties (source rock, migration pathway, timing, trapping mechanism, hydrocarbon type, etc.). For the Paradox and Uinta basins, due to overlapping plays, the EPCA study area boundaries were defined by the outline of Uinta plays. The Uinta/Piceance study areas thus contain portions of some Paradox Basin plays.

- Archaeological reviews required by the National Historic Preservation Act, and related issues involving cultural resources including consultation with Native American tribes;
- Air quality impacts, especially visibility considerations in the Interior West, and resulting restrictions on activities that may affect air quality;
- Visual impacts of oil and gas operations;
- Noise from oil and gas operations;
- Conflicts between oil and gas and other mineral operations, such as coal and potash;
- Suburban encroachment on oil and gas fields and county government restrictions;
- "Sense of Place," i.e., an emotional or spiritual attachment to certain locations which has been used as justification for designating certain areas as off limits to drilling;

Typically these requirements manifest themselves as conditions of approval attached to drilling permits following a specific analysis under the National Environmental Policy Act (NEPA). These requirements can delay or modify a planned oil and gas development activity at the permit stage and in some cases preclude it altogether. Because these requirements were not easily quantifiable, there were not included in this inventory.

The rest of this section provides a more detailed description of the EPCA inventory methodology.

## **2.1 PROCEDURES FOR COLLECTING AND ANALYZING LAND STATUS AND LEASE STIPULATIONS**

### **2.1.1 Land Status**

For the EPCA inventory, all Federal lands<sup>2</sup> and split estate<sup>3</sup> within the study areas were examined.

#### *2.1.1.1 Sources of Land Status Data*

Land status carries with it a complex definition involving both ownership and availability of the surface and mineral estates. Inherent in a Federal mineral lease is a limited right of surface use in order to develop the mineral estate. For the purpose of this inventory, land status refers both to Federal ownership of the oil and gas mineral estate and to the availability of the Federal mineral estate for oil and gas leasing.

The source of Federal land status data is the BLM's Land Status Database. These data, which are stored in alphanumeric format, were converted for this inventory into a GIS layer by using commercially available software. The software interpolated the legal descriptions contained in the Status Database against a public land survey GIS layer derived from either the BLM's Geographic Coordinate Database (GCDB) or other sources such as digitized USGS 7-1/2 minute quadrangle maps.

#### *2.1.1.2 Land Status Data Preparation*

Maps of the Federal land status for the study areas are presented in figures 2a through 2e. See Appendix 3 for a more detailed description of land status data preparation.

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<sup>2</sup> Indian lands were not included in this inventory.

<sup>3</sup> Federal split estate resources are subject to the same Federal restrictions as those implemented on Federal lands because access to these resources through leasing and permitting is a Federal action.

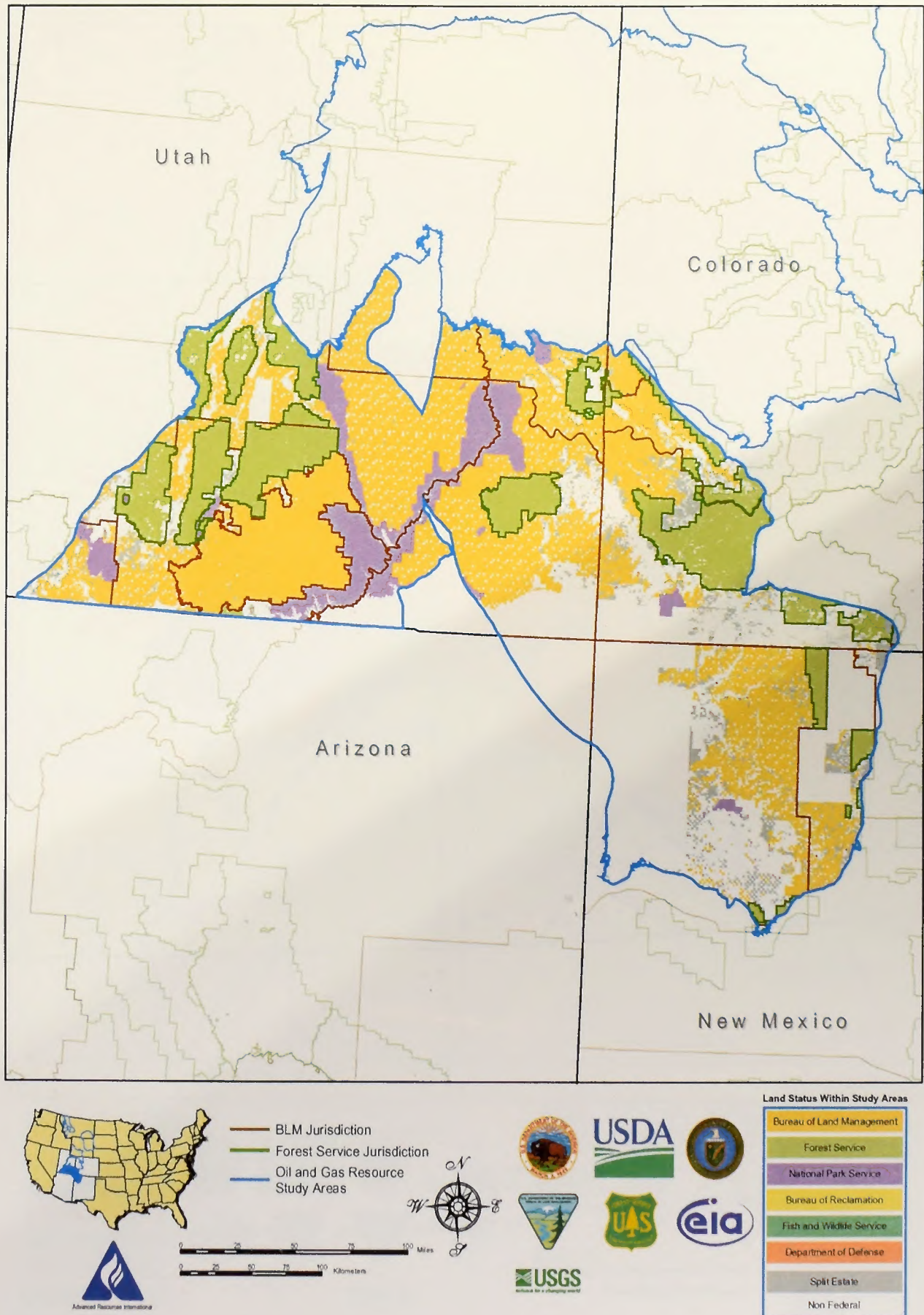


Figure 2a Federal Land Status Map -- Paradox/San Juan Study Area

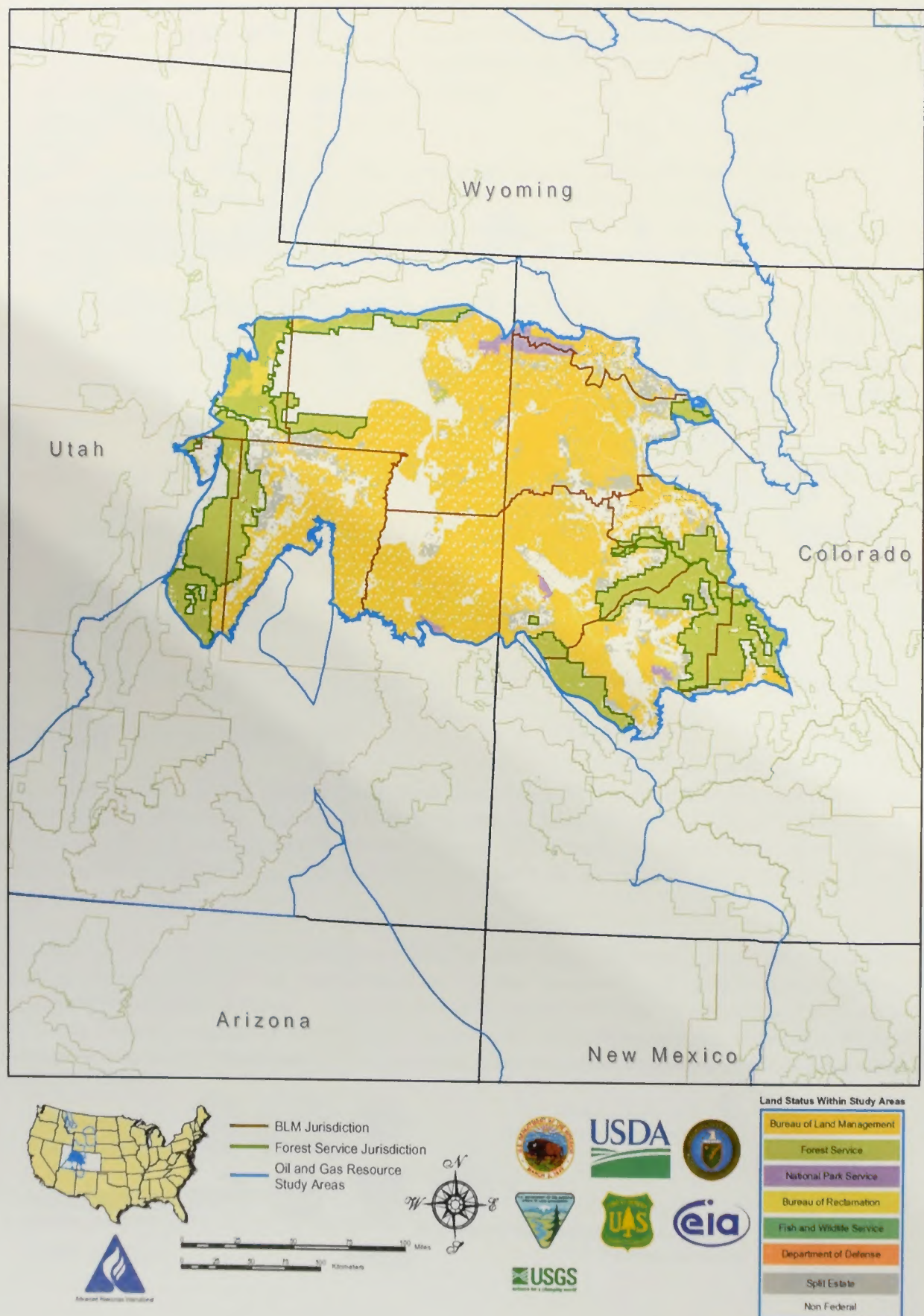


Figure 2b Federal Land Status Map – Uinta/Piceance Study Area

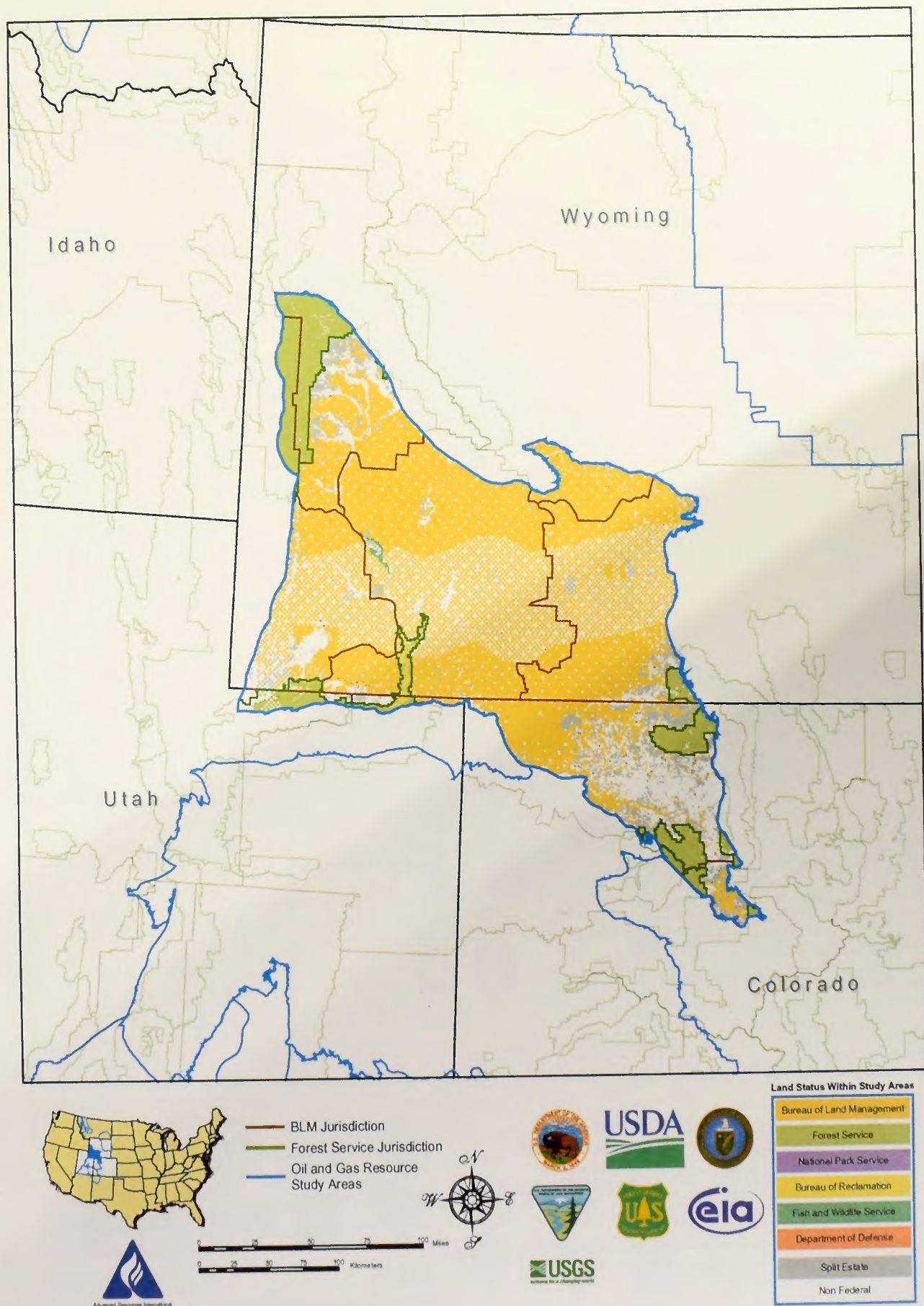


Figure 2c

Federal Land Status Map – Greater Green River Study Area

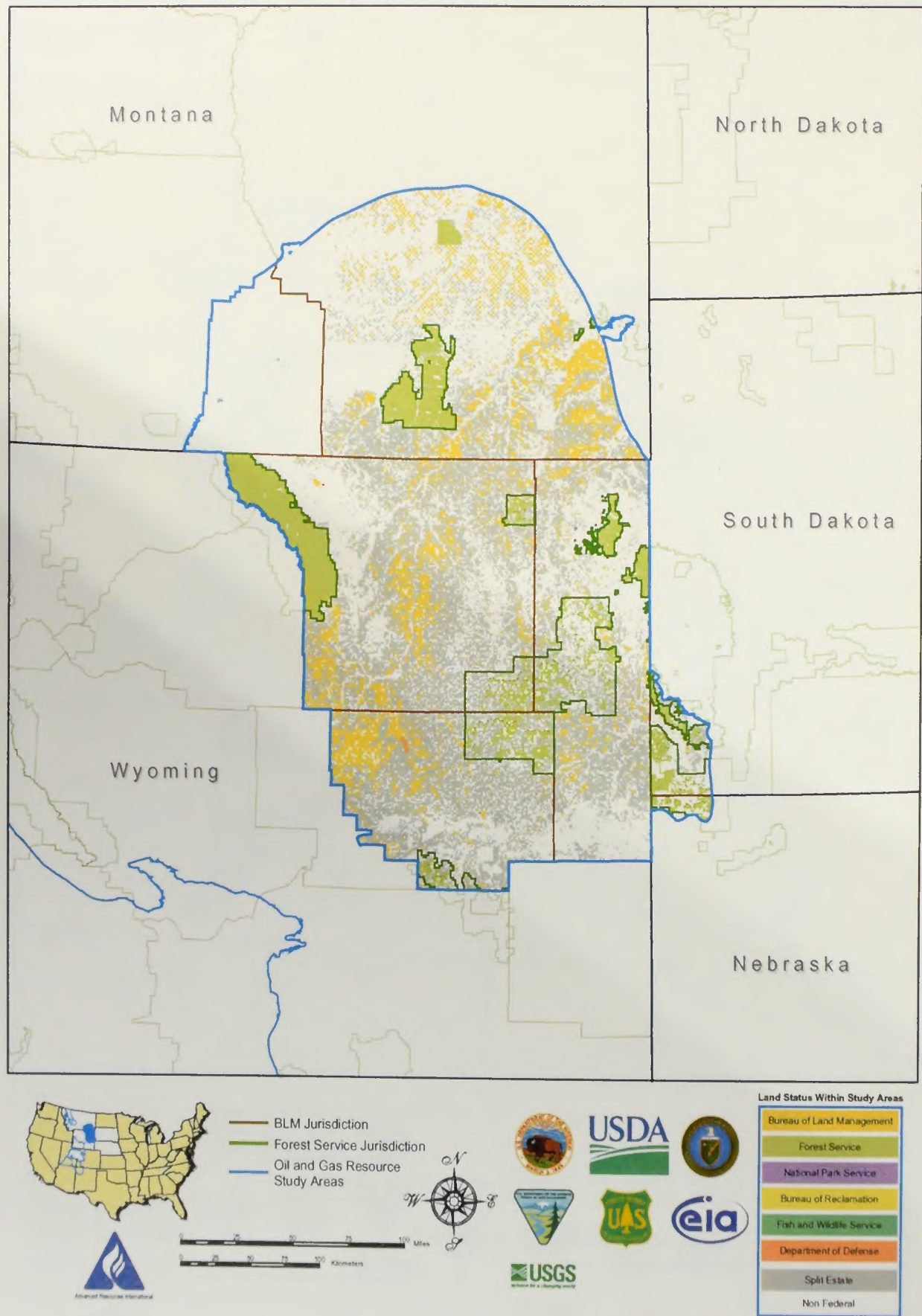


Figure 2d Federal Land Status Map – Powder River Study Area

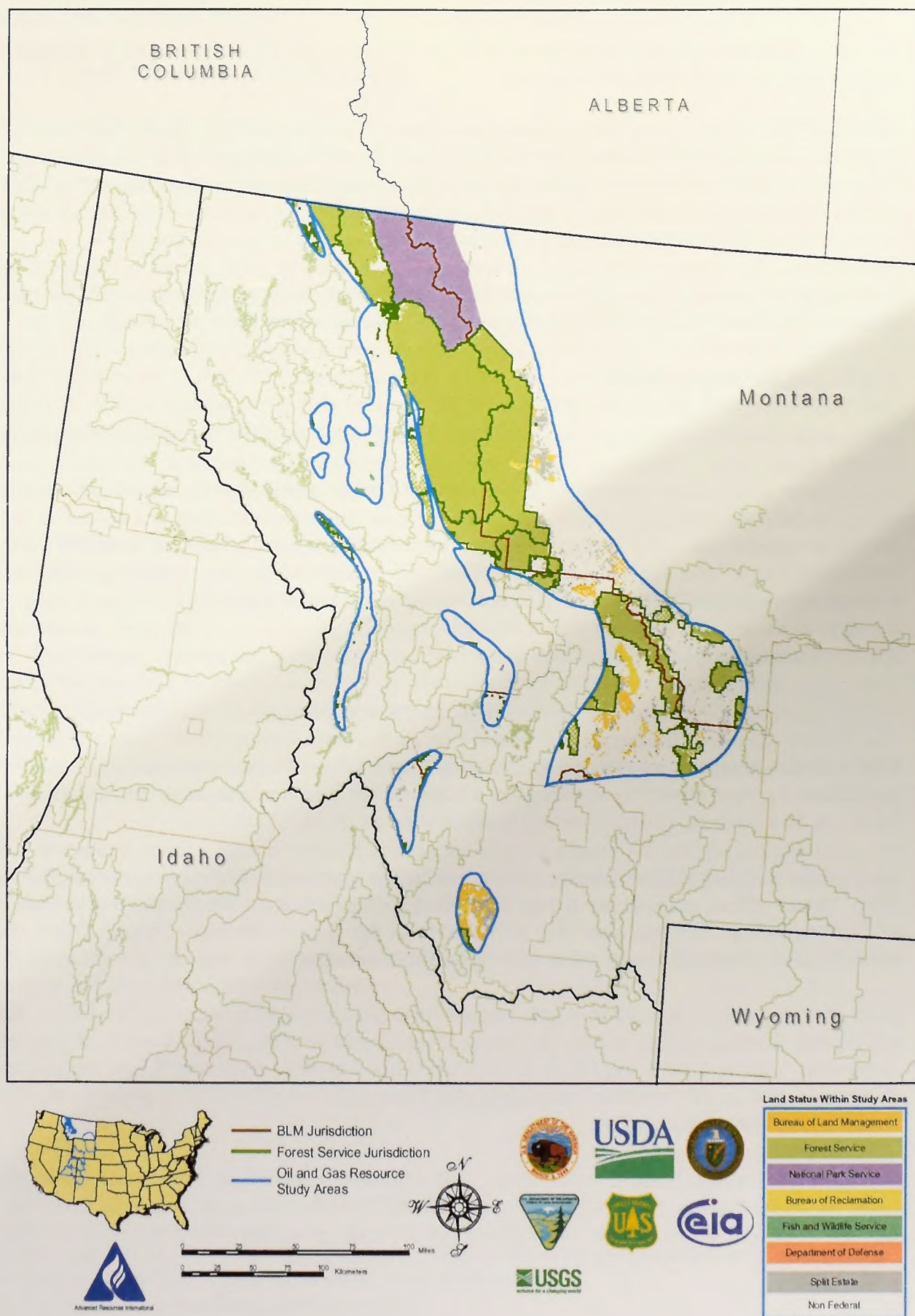


Figure 2e

Federal Land Status Map – Montana Thrust Belt Study Area

### *2.1.1.3 Land Status Data-Related Caveats*

The land status data are spatially accurate down to 40 acres. The BLM considers this information complete and up to date as of August 2002.

The GIS files created using the processes described in Appendix 3 were interpolated from the legal land descriptions contained in BLM's Land Record database. If a legal description referenced a small survey lot or tract by number, a nominal location was mapped through a process that referenced the Legal Land Description dataset. This dataset is limited to a 40-acre description and therefore carries a minor degree of generalization in complex areas.

This mapping process uses public land survey data derived from various sources. The spatial location of the land status parcels so derived matches the accuracy of the survey data.

## **2.1.2 Lease Stipulations**

All Federal onshore oil and gas leases contain terms and conditions specified in the standard Federal lease form. Some of these terms and conditions govern land use and resource development to a certain extent. Environmental and other considerations, which are identified during the land use planning process, determine the need for additional terms and conditions, also known as stipulations. For example, a lease may contain a stipulation that prohibits surface disturbance where land slopes exceed 35 percent. These stipulations may represent constraints to the exploration for and development of oil and natural gas on Federal lands.

### *2.1.2.1 Sources of Lease Stipulation Data*

Oil and gas lease stipulations are derived from the surface management agency's land use plans. The BLM's planning documents are referred to as Resource Management Plans (RMPs); the USDA-Forest Service's are referred to as Forest Plans. These plans are produced and generally maintained by their respective agencies on a Field Office jurisdictional basis (in the case of the BLM), or on a National Forest/Grassland basis (in the case of the USDA-FS).

Most of the lease stipulation data are maintained by the agencies as GIS data layers (digital map files). Some offices, particularly where the planning effort pre-dated the widespread availability of GIS technology, still maintain this information in the form of hardcopy maps. These maps were digitized, stored, and analyzed as GIS layers for this inventory.

Hard copy and digital data showing the mapped lease stipulation areas were collected from BLM and Forest Service offices within the study areas (listed in Table 1a). Copies of guidance documents, such as RMPs and Forest Plans, were also obtained. Appendix 8 lists the guidance documents used in this inventory, and Appendix 9 (available on CD-ROM or website only) lists the actual stipulations themselves.

For the Paradox/San Juan, Powder River, and Montana Thrust Belt study areas, data were collected in the winter of 2001-2002. For the Uinta/Piceance study area, data were collected in the fall of 2001. For the Greater Green River (GGR) study area, data were used from the DOE's

Federal lands analysis<sup>10</sup> collected during the fall and winter of 2000-2001; these data were verified with the local BLM and USDA-FS offices and are current as of August 2002.

#### *2.1.2.2 Lease Stipulation Data Preparation*

The bulk of the data preparation consisted of the gathering, digitizing, and compiling of the gathered data in multi-layered digital map files. Federal Geographic Data Committee Standards (FGDC)-compliant supporting documentation (metadata) for the resulting GIS layers were also created<sup>11</sup>.

This inventory is limited to those Federal lands within the aggregate resource play boundaries of the five study areas, which are based on geology as defined in the USGS National Assessment of Oil and Gas Resources. The land status and stipulation digital map files, which corresponded to Federal land management agency jurisdiction boundaries, were cut to fit within each of the study area boundaries using the GIS. Data contained within the compiled digital map files were then queried for unique leasing stipulation values. The results were then saved as separate map files. Each digital map file represents a unique stipulation value.

For an example of the specific data preparation steps, see Appendix 4.

#### *2.1.2.3 Lease Stipulation Data-Related Caveats*

All stipulations for which GIS data were available from the Federal land management agencies were used in the analysis. A majority of the stipulations within the study areas were available in GIS data formats. However, supporting documentation was not generally provided with GIS files. This can lead to inaccuracies due to undocumented differences in technical parameters. Any such errors are minor in terms of the scope of the inventory.

Stipulations not available in GIS format were digitized and any resulting inaccuracies have only minor effects upon the analysis.

In a few cases neither hardcopy nor digital maps were available for certain stipulations. The result is that the ensuing analyses may underestimate the extent of restrictions on land access. This occurred for less than 10 percent of the stipulations.

The lease stipulation data are generally accurate to 40 acres. The information is considered complete and up to date as of August 2002.

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<sup>10</sup> Federal Lands Analysis, Natural Gas Assessment, Southern Wyoming and Northwestern Colorado, Study Methodology and Results, June 2001, available on the DOE website: [http://fossil.energy.gov/techline/tl\\_ggrb\\_gas.shtml](http://fossil.energy.gov/techline/tl_ggrb_gas.shtml).

<sup>11</sup> GIS layers from surface management agency land status, stipulations, and the analyses, as well as the associated metadata, are available on the CD-ROMs and the web sites.

## 2.2 PROCEDURES FOR COLLECTING AND ANALYZING OIL AND GAS RESOURCE DATA

### 2.2.1 Sources of Oil and Gas Resource Data

In conformance with EPCA, the volumes of undiscovered technically recoverable oil and gas resources in each oil and gas play are supplied exclusively by the USGS.

#### **Oil and gas resources occur in four categories:**

The *In-place resource* is the total volume of oil and gas thought to exist (both discovered and yet-to-be discovered) without regard to the ability to either access or produce it. Although the in-place resource is primarily a fixed, unchanging volume, the current understanding of that volume is continually changing as technology improves.

*Technically recoverable resources* are a subset of the in-place resource that includes only that oil and gas (both discovered and undiscovered) that is expected to be producible given *available* technology with no regard to current costs. Technically-recoverable resources are therefore dynamic, constantly changing to reflect our increased understanding of both the in-place resource as well as the likely nature of future technology.

*Economically recoverable resources* are a subset of the technically recoverable that includes only that oil and gas that is expected to be producible at a profit. This is a very dynamic category, changing not only with increasing knowledge and technology, but also with the rapid and sometimes unpredictable changes in economic conditions, prices, and regulation.

*Reserves* are oil and gas that has been proven by drilling and is available for profitable production. Reserves are also subject to economic conditions.

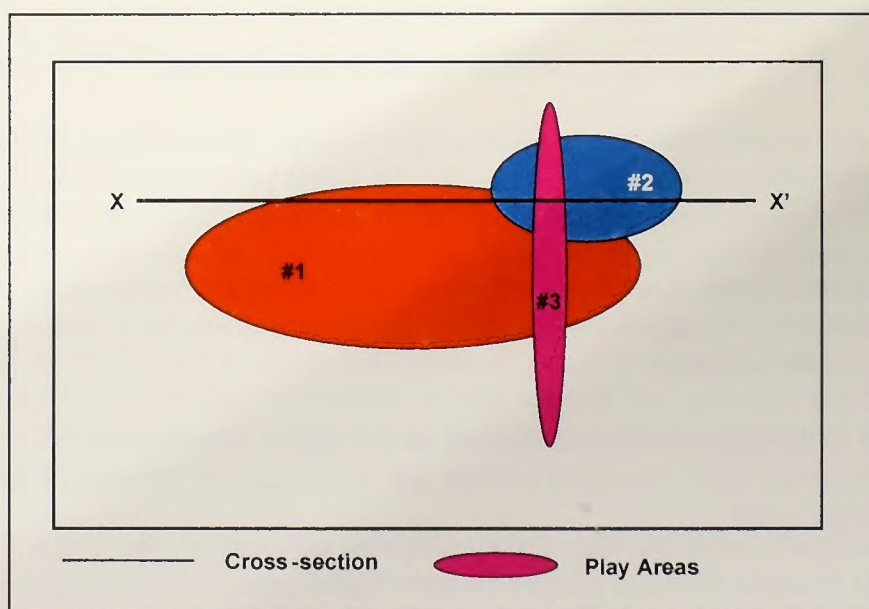
Technically recoverable resources are those hydrocarbon resources that, on the basis of geologic information and theory, are estimated to exist outside of known producing fields. This class of hydrocarbon resources is that which can be produced using current technology but without regard to economic profitability. Technically recoverable resources are the subset of resources-in-place that could be expected to be recovered over an exploration and development life cycle measured in decades.

An economic analysis of the undiscovered technically recoverable resources would require a number of assumptions about future costs of exploration and development, transportation and infrastructure that can change significantly with time. Such an analysis is a subjective exercise, and is not appropriate for Federal land use decisions or allocation. An economic analysis on a project-specific basis is most appropriate when used by the private sector in its decision making process.

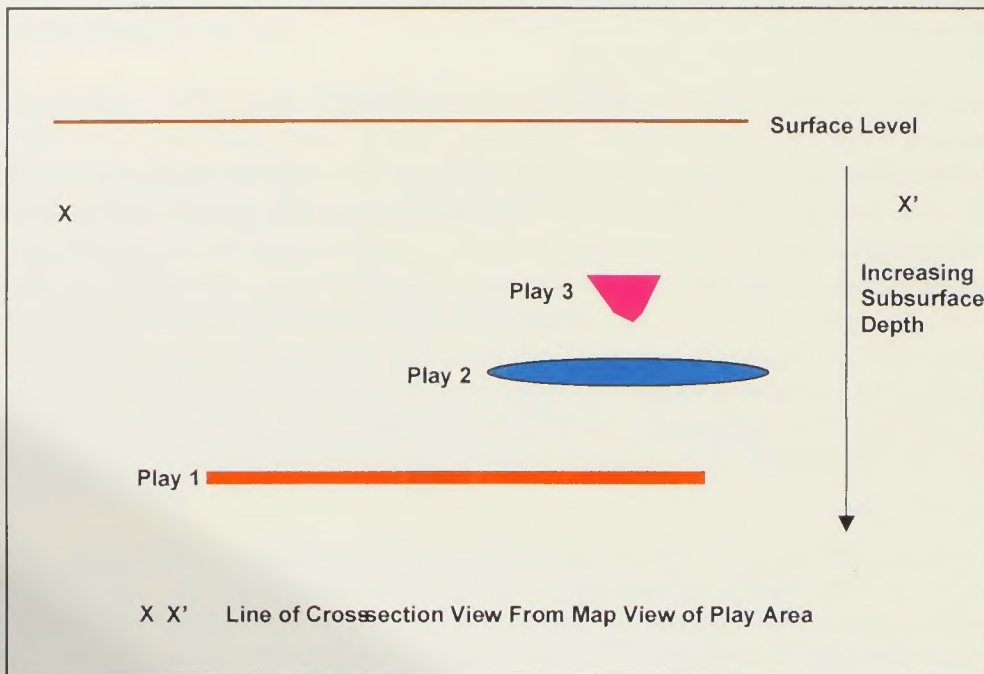
The resources included in this study comprise oil, natural gas liquids (NGLs), associated dissolved (AD) natural gas, non-associated (NA) natural gas and liquids in gas reservoirs. Oil is a natural liquid of mostly hydrocarbon molecules. NGLs are liquid when produced to the surface but exist in the gas phase in the subsurface. Natural gas is a mixture of hydrocarbon gases consisting primarily of methane. Associated dissolved natural gas is that produced from oil fields, whereas non-associated natural gas is that produced "dry" from gas fields. The USGS assesses technically recoverable resources for each of these resource types, and those volumes were provided for this effort. However, for this inventory, undiscovered oil, NGL, and liquids

associated with natural gas reservoirs were subsequently merged into a single "Total Liquids" resource category (table 2a).

The USGS uses the resource "play" as the unit of assessment. A play is defined by a set of common geological conditions (source rock, migration, charge, traps, seals, etc.) that characterize a group of hydrocarbon accumulations in the subsurface. The USGS specifically states in the assessment process that resource volumes are not homogeneously distributed within a play. However, a homogeneous distribution of resource within a play boundary is assumed for the GIS analysis in this inventory in the absence of more specific information. Nonetheless, variation in the vertical sense is captured by the use of play stacking. The geometry of a resource play is defined by geological environments and has horizontal and vertical expression. The areal extent of resource plays is represented in map view (figure 2f) by vertically projecting their subsurface locations to the surface. In cross-section, the relative depths of individual plays are represented in figure 2g. The plays are commonly "stacked" in the subsurface so that a given surface land parcel can overlie numerous plays.



*Figure 2f*      *Map View of Resource Plays*



*Figure 2g*      *Cross Section of Resource Plays*

In this inventory, there are two resource play types: conventional and continuous (unconventional, which includes coalbed gas). Conventional plays contain discrete hydrocarbon accumulations often associated with hydrocarbon/water contacts. Continuous plays exist as pervasive accumulations that can cross rock unit boundaries, lack discrete borders and exhibit other atypical reservoir properties (figure 2h). The majority of the resources in the study areas are continuous in nature. Compared to conventional plays, continuous accumulations typically are more geographically extensive.

Coalbed methane (CBM), also known as coalbed natural gas, is natural gas from coal beds and is one form of continuous play. Coalbed natural gas resources are the second largest resource component in this inventory.

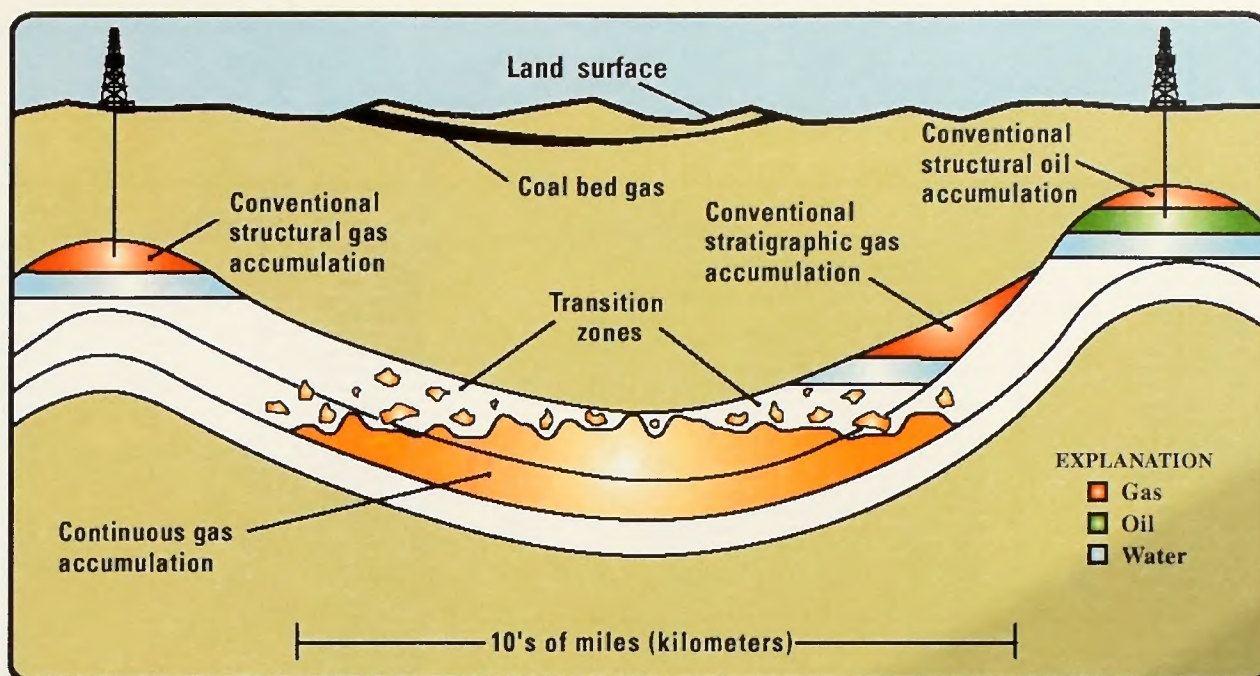


Figure 2h. Conventional vs. Continuous Accumulations

## 2.2.2 Oil and Gas Resource Data Preparation

The USGS identified eighty-eight discrete plays of oil and natural gas resources in the EPCA inventory areas. The mean probabilistic estimates of hydrocarbon resource volumes for each USGS-defined play were utilized for this inventory (Table 2a).

For this inventory, an important simplifying assumption was made that the oil and gas resources are evenly distributed within each resource play area. Therefore, resource volume is calculated to be proportional to surface area within each play. A resource density map for each basin was created in the GIS by a spatial summation of the oil and gas volumes contributed by each resource play. The densities are expressed as thousand cubic feet (MCF) of gas per acre and barrels (BBL) of oil per acre.

The products of the oil and gas resource data preparation work are maps of hydrocarbon volumes, projected to the surface. These maps depict areas of varying potential resource richness based on play resource volumes and play stacking. The distributions of undiscovered technically recoverable resources are shown by study area for liquids in figures 2i through 2m and for gas in figures 2n through 2r. See Appendix 5 for a more detailed description of the USGS methodology for the assessment and allocation of undiscovered oil and gas resources.

Section 2  
Methodology

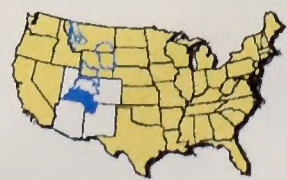
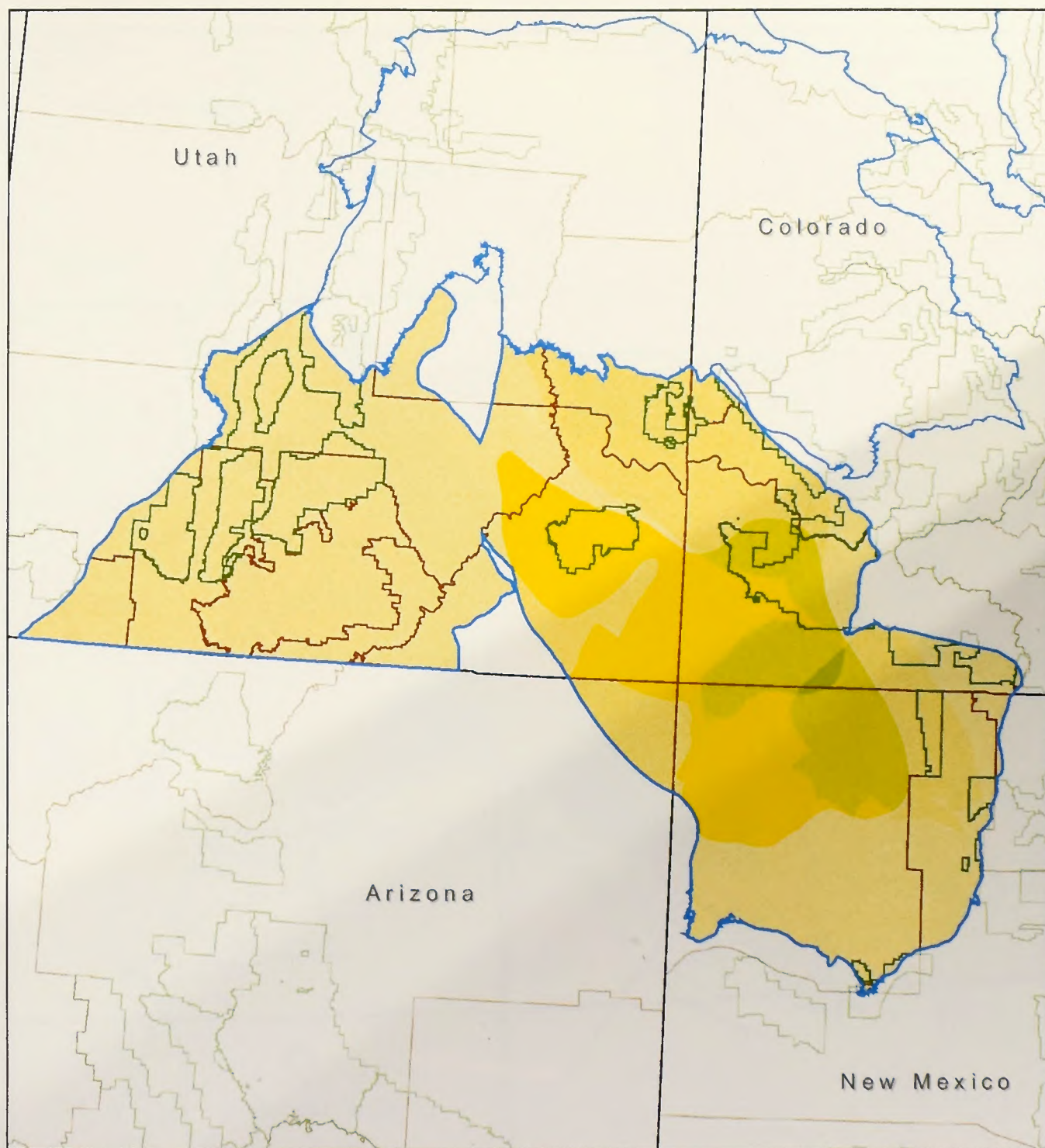
USGS Province Name	USGS Code	USGS Play or Assessment Unit Name	Play Type	Total Liquids** (MMBbl)	Total Natural Gas*** (Bcf)
Paradox Basin	2101	Buried Fault Blocks, Older Paleozoic	Conventional	62	292
Paradox Basin	2102	Porous Carbonate Buildup	Conventional	192	462
Paradox Basin	2103	Fractured Interbed	Continuous	242	194
Paradox Basin	2104	Permian-Pennsylvanian Marginal Clastics	Conventional	3	56
Paradox Basin	2105	Salt Anticline Flank	Conventional	20	396
Paradox Basin	2106	Permo-Triassic Unconformity	Conventional	21	2
Paradox Basin	2107	Cretaceous Sandstone	Conventional		56
San Juan Basin	50220101	Tertiary Conventional Gas	Conventional	1	60
San Juan Basin	50220161	Pictured Cliffs Continuous Gas	Continuous Gas	17	5,640
San Juan Basin	50220161	Fruitland Fairway Coalbed Gas	Coalbed Gas		3,961
San Juan Basin	50220182	Basin Fruitland Coalbed Gas	Coalbed Gas		19,695
San Juan Basin	50220261	Lewis Continuous Gas	Continuous Gas	31	10,177
San Juan Basin	50220302	Gallup Sandstone Conventional Oil and Gas	Conventional	2	< 5
San Juan Basin	50220303	Mancos Sandstones Conventional Oil	Conventional	14	56
San Juan Basin	50220304	Dakota-Greenhorn Conventional Oil and Gas	Conventional	3	22
San Juan Basin	50220361	Mesaverde Central-Basin Continuous Gas	Continuous Gas	5	1,317
San Juan Basin	50220362	Mancos Sandstones Continuous Gas	Continuous Gas	76	5,116
San Juan Basin	50220363	Dakota-Greenhorn Continuous Gas	Continuous Gas	16	3,929
San Juan Basin	50220361	Menefee Coalbed Gas	Coalbed Gas		664
San Juan Basin	50220401	Entrada Sandstone Conventional Oil	Conventional		6
Uinta - Piceance Basin	50200101	Conventional Ferron Sandstone Gas	Conventional	< 5	40
Uinta - Piceance Basin	50200161	Deep (6,000 feet plus) Coal and Sandstone Gas	Continuous Gas		59
Uinta - Piceance Basin	50200161	Northern Coal Fairway/Drunkards Wash	Coalbed Gas		752
Uinta - Piceance Basin	50200182	Central Coal Fairway/Buzzards Bench	Coalbed Gas		537
Uinta - Piceance Basin	50200183	Southern Coal Fairway	Coalbed Gas		153
Uinta - Piceance Basin	50200164	Joes Valley and Messina Grabens	Coalbed Gas		NA
Uinta - Piceance Basin	50200165	Southern Coal Outcrop	Coalbed Gas		11
Uinta - Piceance Basin	50200201	Uinta-Piceance Basin Conventional Gas	Conventional	1	66
Uinta - Piceance Basin	50200261	Uinta Basin Continuous Gas Mesaverde TPS	Continuous Gas	11	7,391
Uinta - Piceance Basin	50200262	Uinta Basin Transitional Gas	Continuous Gas	2	1,493
Uinta - Piceance Basin	50200263	Piceance Basin Continuous Gas Mesaverde TPS	Continuous Gas	9	3,064
Uinta - Piceance Basin	50200264	Piceance Basin Transitional Gas	Continuous Gas	1	302
Uinta - Piceance Basin	50200261	Uinta Basin Blackhawk Coalbed Gas	Coalbed Gas		499
Uinta - Piceance Basin	50200262	Mesaverde Group Coalbed Gas	Coalbed Gas		366
Uinta - Piceance Basin	50200361	Piceance Basin Continuous Gas Mancos/Mowry TPS	Continuous Gas	2	1,653
Uinta - Piceance Basin	50200362	Uinta Basin Continuous Gas Mancos/Mowry TPS	Continuous Gas	6	3,111
Uinta - Piceance Basin	50200363	Uinta-Piceance Transitional and Migrated Gas	Continuous Gas	2	1,755
Uinta - Piceance Basin	50200401	Hanging Wall	Conventional	5	26
Uinta - Piceance Basin	50200402	Paleozoic/Mesozoic	Conventional	8	50
Uinta - Piceance Basin	50200501	Uinta Green River Conventional Oil and Gas	Conventional	11	29
Uinta - Piceance Basin	50200502	Piceance Green River Conventional Oil	Conventional	NA	
Uinta - Piceance Basin	50200561	Deep Uinta Overpressured Continuous Oil	Continuous Oil	43	64
Southwestern Wyoming	50370101	Sub-Cretaceous Conventional Oil and Gas	Conventional	58	1,383
Southwestern Wyoming	50370201	Mowry Conventional Oil and Gas	Conventional	12	206
Southwestern Wyoming	50370401	Hilliard-Baxter-Mancos Conventional O&G	Conventional	1	15
Southwestern Wyoming	50370501	Mesaverde Conventional Oil and Gas	Conventional	3	56
Southwestern Wyoming	50370601	Mesaverde-Lance-Fort Union Conventional O&G	Conventional	17	320
Southwestern Wyoming	50370701	Lewis Conventional Oil and Gas	Conventional	6	195
Southwestern Wyoming	50370601	Lance-Fort Union Conventional Oil and Gas	Conventional	2	246
Southwestern Wyoming	50370361	Niobrara Continuous Oil	Continuous Oil	107	62
Southwestern Wyoming	50370261	Mowry Continuous Gas	Continuous Gas	171	6,543
Southwestern Wyoming	50370461	Hilliard-Baxter-Mancos Continuous Gas	Continuous Gas	752	11,753
Southwestern Wyoming	50370561	Almond Continuous Gas	Continuous Gas	200	13,350
Southwestern Wyoming	50370662	Rock Springs-Ericson Continuous Gas	Continuous Gas	146	12,176
Southwestern Wyoming	50370661	Mesaverde-Lance-Fort Union Continuous Gas	Continuous Gas	614	13,635
Southwestern Wyoming	50370761	Lewis Continuous Gas	Continuous Gas	541	13,536
Southwestern Wyoming	50370861	Lance-Fort Union Continuous Gas	Continuous Gas	76	7,563
Southwestern Wyoming	50370561	Mesaverde Coalbed Gas	Coalbed Gas		249
Southwestern Wyoming	50370661	Mesaverde Coalbed Gas	Coalbed Gas		27
Southwestern Wyoming	50370662	Fort Union Coalbed Gas	Coalbed Gas		61
Southwestern Wyoming	50370661	Lance Coalbed Gas	Coalbed Gas		165
Southwestern Wyoming	50370662	Fort Union Coalbed Gas	Coalbed Gas		943
Southwestern Wyoming	50370961	Wasatch-Green River Coalbed Gas	Coalbed Gas		65
Powder River Basin	3301	Basin Margin Subthrust	Conventional	21	20
Powder River Basin	3302	Basin Margin Anticline	Conventional	7	4
Powder River Basin	3303	Leo Sandstone	Conventional	81	5
Powder River Basin	3304	Upper Minnelusa Sandstone	Conventional	522	31
Powder River Basin	3305	Lakota Sandstone	Conventional	55	22
Powder River Basin	3306	Fall River Sandstone	Conventional	200	115
Powder River Basin	3307	Muddy Sandstone	Conventional	66	449
Powder River Basin	3309	Deep Frontier Sandstone	Conventional	56	193
Powder River Basin	3310	Turner Sandstone	Conventional	25	32
Powder River Basin	3312	Sussex-Shannon Sandstone	Conventional	72	54
Powder River Basin	3313	Mesaverde-Lewis	Conventional	62	56
Powder River Basin	50330101	E. Basin Margin Upper Fort Union Sandstone	Conventional		27
Powder River Basin	50330151	Wasatch Formation	Coalbed Gas		1,934
Powder River Basin	50330162	Upper Fort Union Formation	Coalbed Gas		12,132
Powder River Basin	50330163	Lower Fort Union-Lance Formations	Coalbed Gas		196
Powder River Basin	50330261	Mowry Continuous Oil Assessment Unit	Continuous Oil	209	196
Powder River Basin	50330361	Niobrara Continuous Oil Assessment Unit	Continuous Oil	240	227
Powder River Basin	50330461	Shallow Continuous Biogenic Gas AU	Continuous Gas		767
Montana Thrust Belt	50270101	Thrust Belt Conventional Gas and Oil	Conventional	134	5,761
Montana Thrust Belt	50270102	Sawtooth Range Structure Conventional O&G	Conventional	16	795
Montana Thrust Belt	50270103	Frontal Structures Conventional Oil and Gas	Conventional	66	1,192
Montana Thrust Belt	50270201	Helena Salient Conventional Oil and Gas	Conventional	15	639
Montana Thrust Belt	50270401	Blacktail Salient Conventional Oil and Gas	Conventional	6	16
Montana Thrust Belt	50270561	Marias River Shale Continuous Oil	Continuous Oil	33	111
Montana Thrust Belt	50270701	Tertiary Basins Oil and Gas	Conventional	73	124
Totals				6,610	163,204

\* All values are mean resource values from the USGS National Assessment of Oil and Gas Resources (assessment unit resources from the 2002 Update; play resources from the 1995 Oil and Gas Assessment).

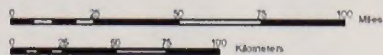
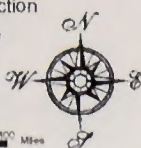
\*\* Comprising oil, NGLs and liquids associated with natural gas reservoirs.

\*\*\* Comprising associated dissolved and nonassociated natural gas.

NA - not assessed



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



Total Liquids  
Thousands of Barrels Per Square Mile

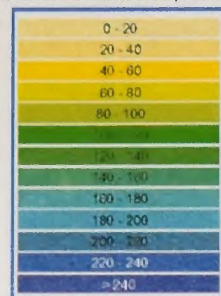


Figure 2i

Total Liquids Map – Paradox/San Juan Study Area

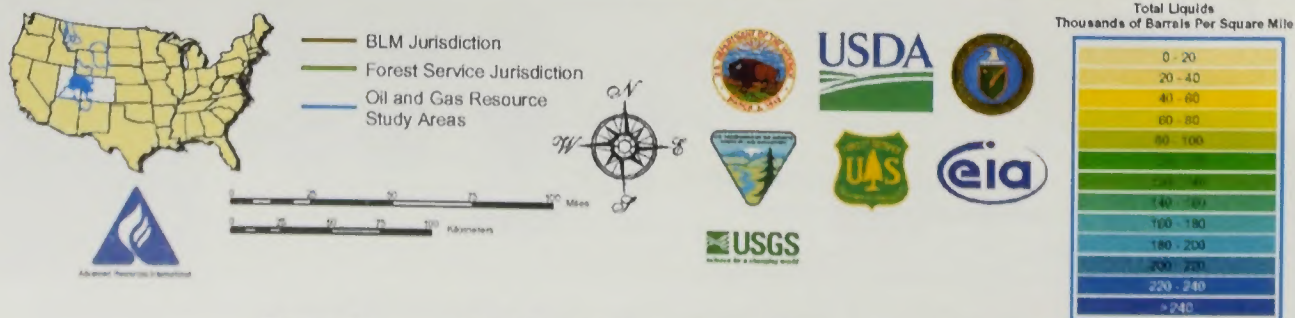


Figure 2j Total Liquids Map – Uinta/Piceance Study Area

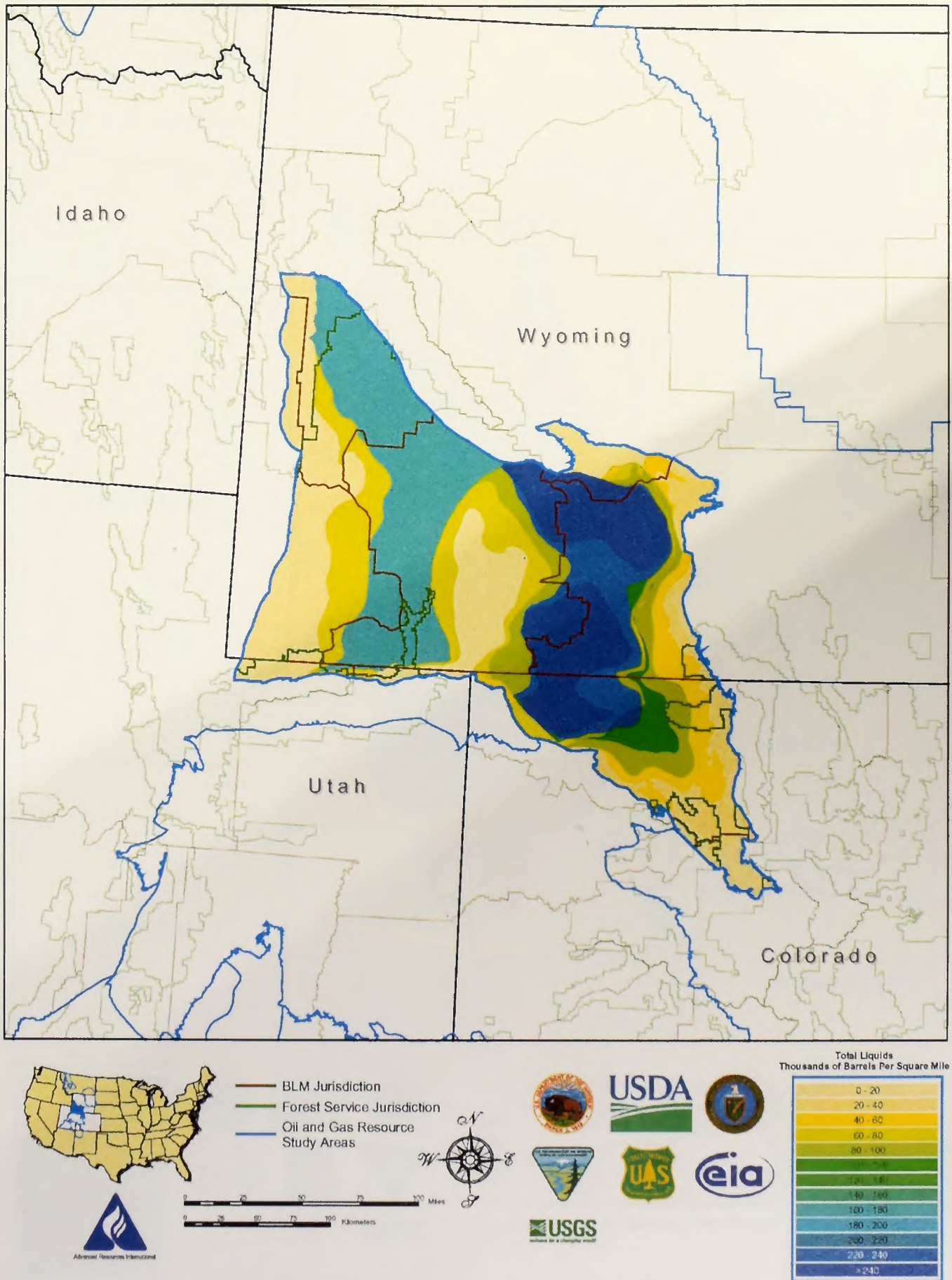


Figure 2k

Total Liquids Map – Greater Green River Study Area

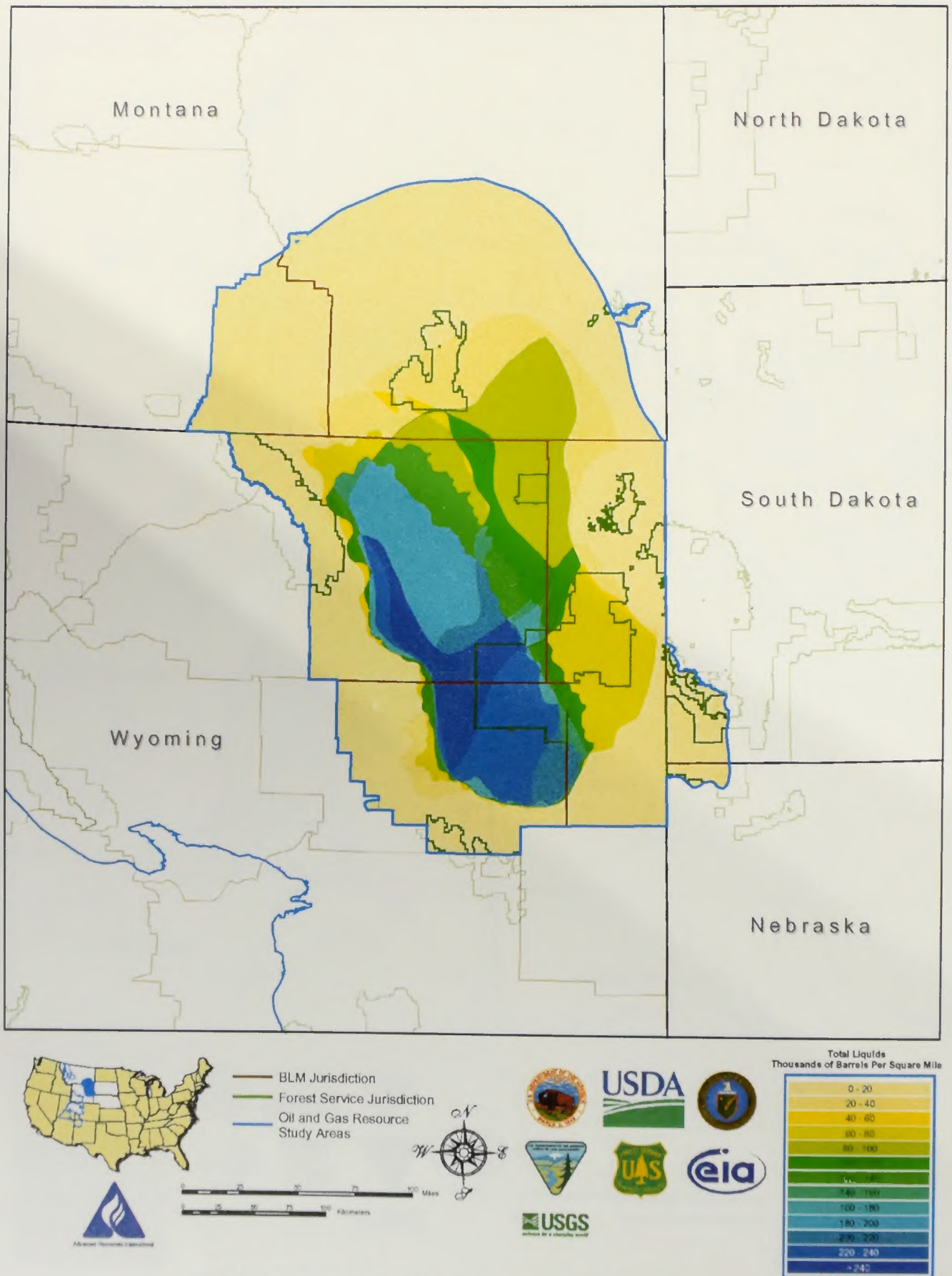


Figure 21 Total Liquids Map – Powder River Study Area

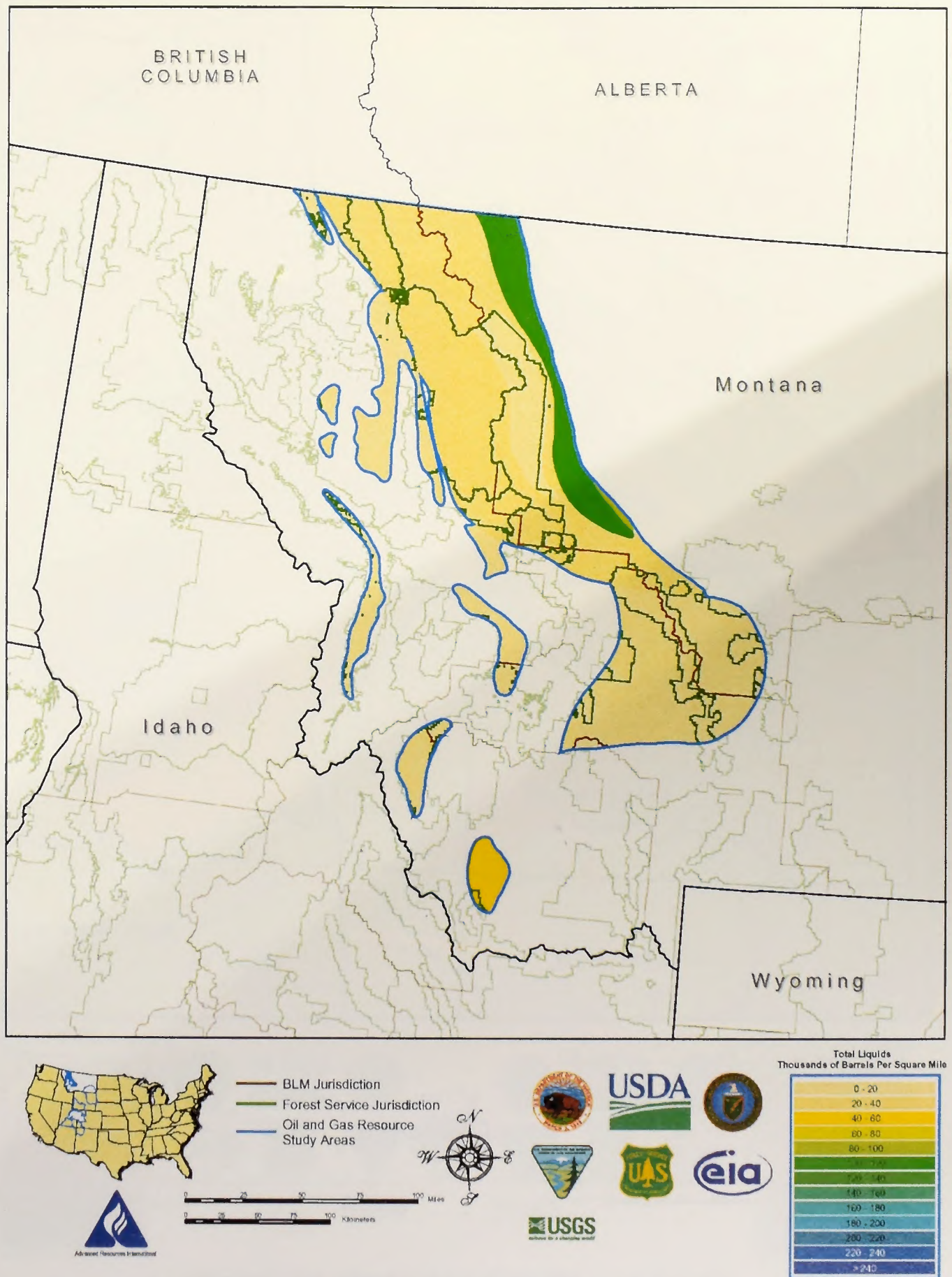


Figure 2m Total Liquids Map – Montana Thrust Belt Study Area

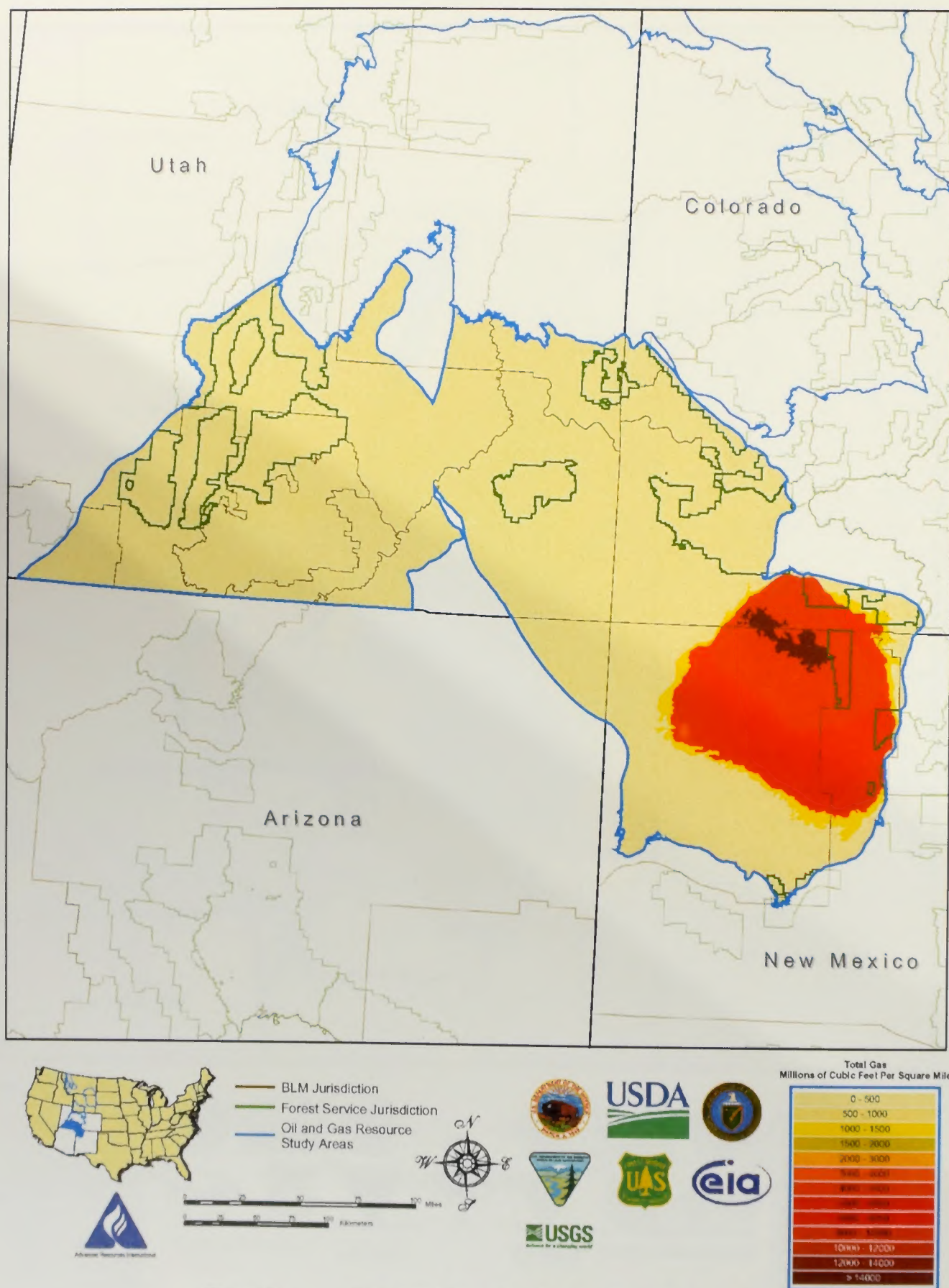
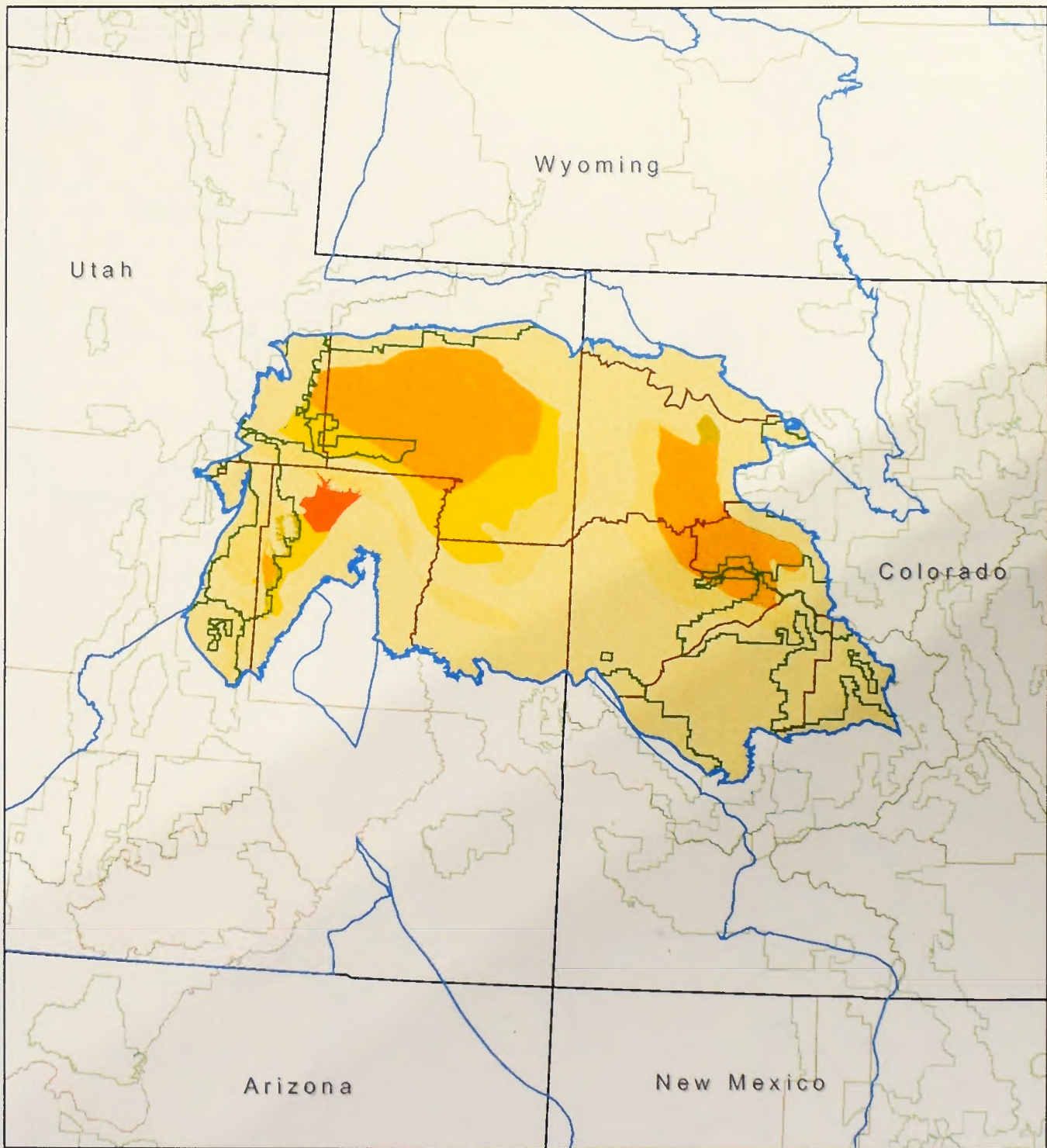
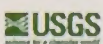
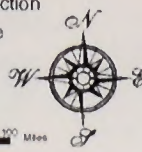


Figure 2n Total Gas Map – Paradox/San Juan Study Area



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



Total Gas  
Millions of Cubic Feet Per Square Mile

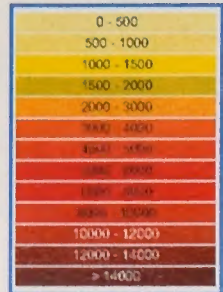
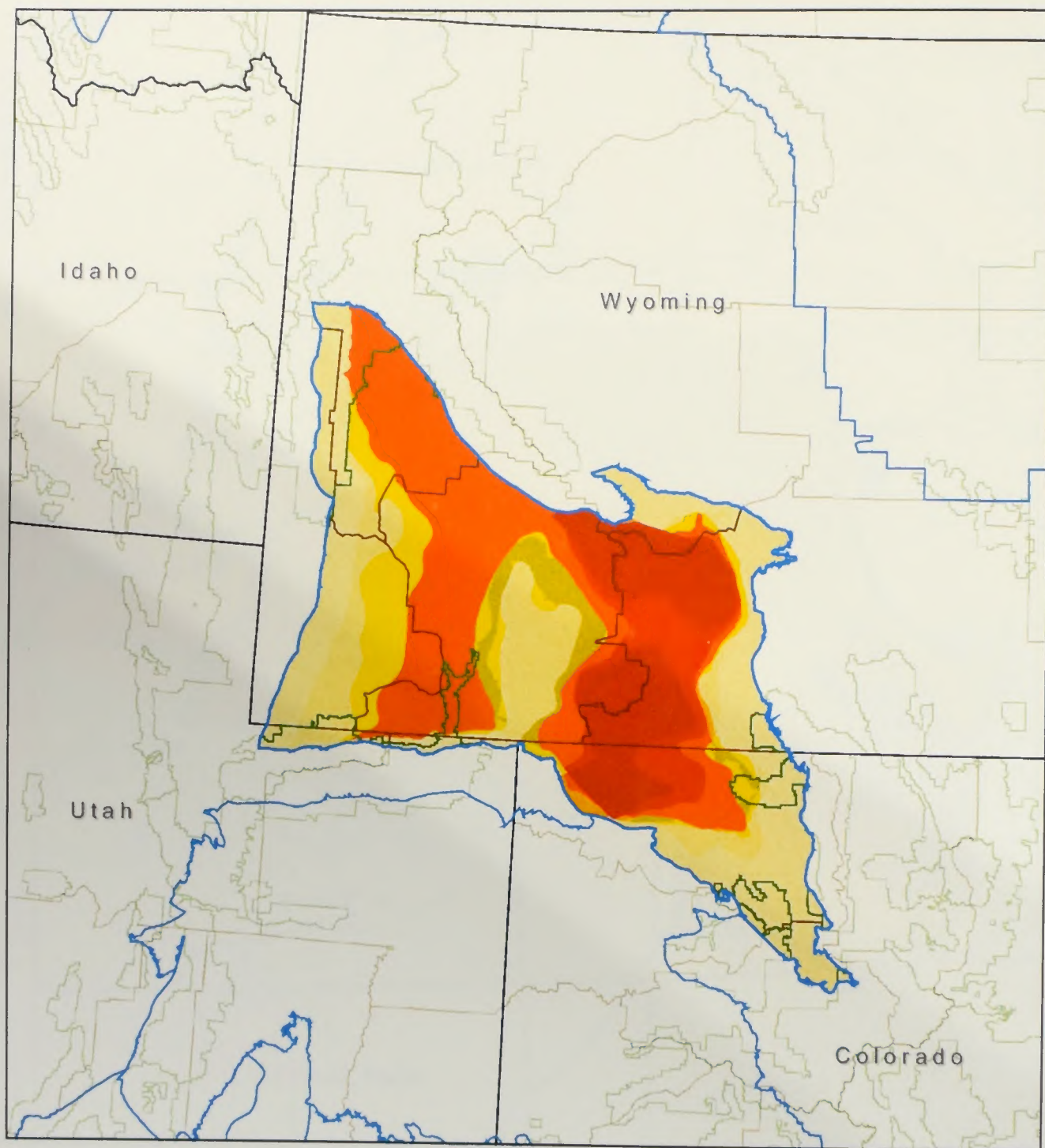
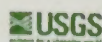
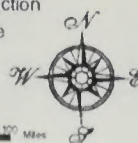


Figure 20 Total Gas Map – Uinta/Piceance Study Area



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas

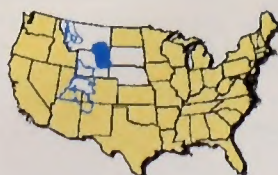
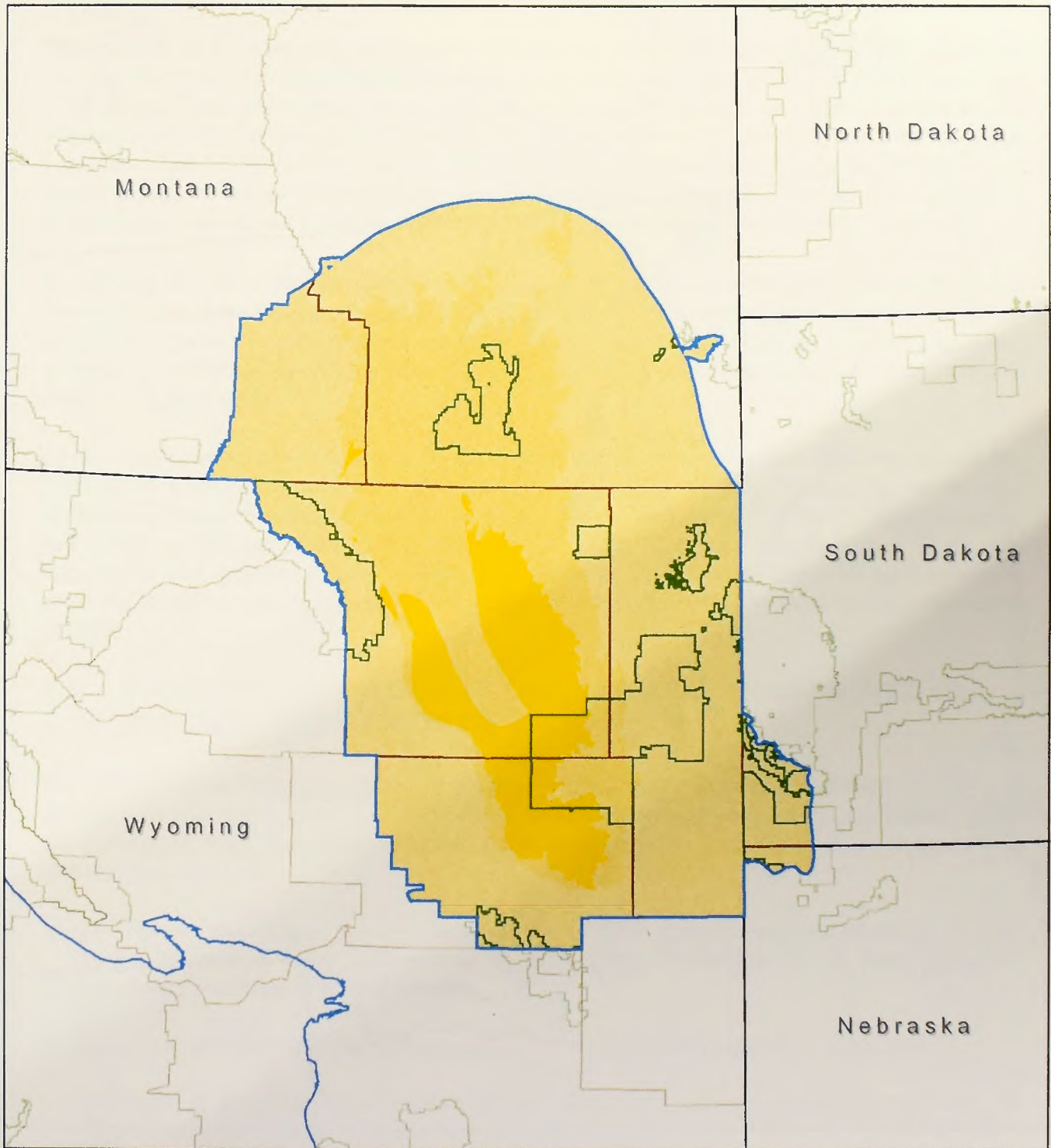


Total Gas  
Millions of Cubic Feet Per Square Mile

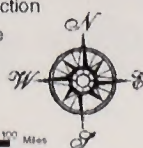
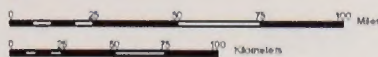


Figure 2p

Total Gas Map – Greater Green River Study Area



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



Total Gas  
Millions of Cubic Feet Per Square Mile

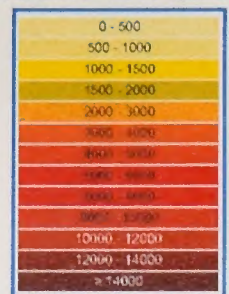


Figure 2q . Total Gas Map – Powder River Study Area

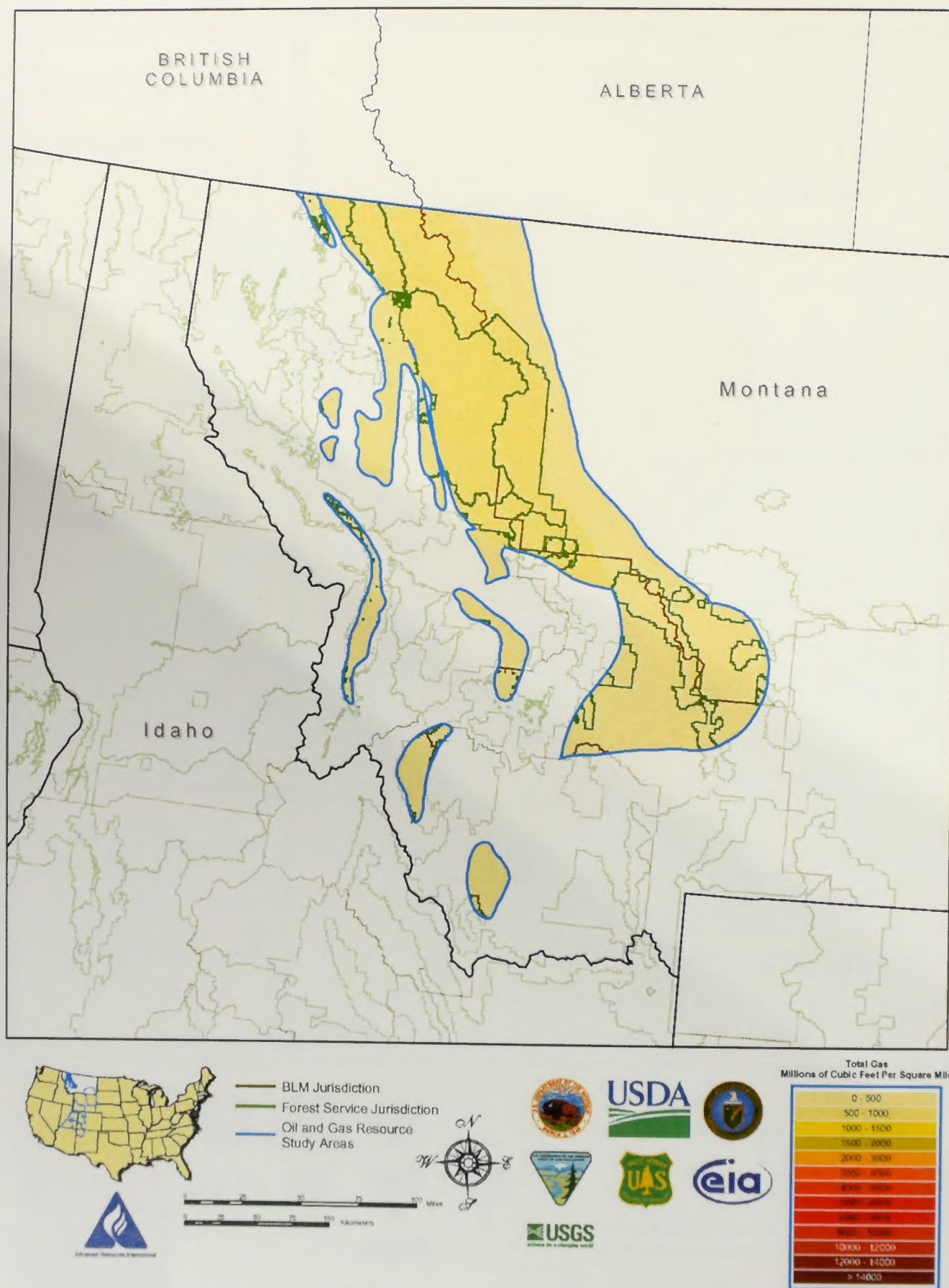


Figure 2r Total Gas Map – Montana Thrust Belt Study Area

### 2.2.3 Oil and Gas Resource Data-Related Caveats

The estimation of technically recoverable resources is inherently uncertain, as reflected by the fact that the USGS develops cumulative probability distributions for the resource estimates of all of its plays. These distributions are used to derive 95 percent probable (a 19-in-20 chance of that volume or more), 5 percent probable (a 1-in-20 chance of that much or more) and mean resource volumes. The mean volume, used in this inventory, represents the arithmetic average of all possible resource outcomes weighted by their probability of occurrence. Therefore, the analytical results shown here do not explicitly reflect the range of uncertainty in the resource assessments.

In addition, not all of the resource plays recognized by the USGS within the boundaries of this inventory have been evaluated, typically because there are hypothetical plays that lack sufficient supporting data to calculate resource estimates. To the extent that these plays contain significant volumes of resources, the results presented here would be different relative to a larger resource base.

Given these considerations, it should be understood that no resource assessments are set in stone. Not only is it difficult to accurately assess the resource at any one point in time, but the resource itself is constantly changing in response to the advance of technology and the evolving economic and policy conditions under which extraction is likely to occur. Nonetheless, it is of vital importance that accurate and up-to-date assessments of the potential resources are continually provided to ensure that public policy decisions are conducted with the most timely information possible.

## 2.3 PROCEDURES FOR COLLECTING AND ANALYZING PROVED OIL AND GAS RESERVES DATA

The EPCA Section 604 responsibility of the Energy Information Administration is to provide data and analysis relevant to proved reserves of crude oil, natural gas, and natural gas liquids which are associated with already discovered fields that underlie Federal onshore lands. This responsibility involves:

- provision of estimates of proved reserves for these fields at the highest possible level of detail consonant with a legal requirement to protect the confidentiality of field operators' proprietary estimates of proved reserves,
- estimation of future ultimate recovery appreciation for currently producing fields, and
- provision of inputs to the estimation of additional land access requirements that may be consequent to the expected ultimate recovery appreciation.

Proved reserves are defined as those quantities of crude oil, natural gas, or natural gas liquids that geological and engineering data demonstrate with reasonable certainty (defined as 90 percent or more probable) to be recoverable *in future years* from *known* reservoirs *under existing economic and operating conditions*. Proved reserves are, in effect, the current “inventory on-the-shelf” portion of the total resource endowment.<sup>4</sup>

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<sup>4</sup> The full technical definition of proved reserves is available on the Society of Petroleum Engineers website at [http://www.spe.org/spe/cda/views/shared/viewChannelsMaster/0,2883,1648\\_19738\\_19746\\_24741,00.html](http://www.spe.org/spe/cda/views/shared/viewChannelsMaster/0,2883,1648_19738_19746_24741,00.html)

Estimates of future ultimate recovery appreciation (URA), sometimes referred to as “reserves growth” are not included as a part of this analysis. The URA estimate will be provided as part of a future revision to this inventory.

### 2.3.1 Sources and Data-Related Caveats of Proved Oil and Gas Reserves Data

Comprehensive deterministic estimates of the domestic proved reserves of crude oil, natural gas, and natural gas liquids are prepared annually by the EIA. These estimates are a combination of reported and statistically imputed volumes based on:

- thousands of individual proved reserves and production estimates reported annually either at the field level or at the State level as described below, submitted to EIA by a statistical sample of the operators of domestic oil and gas wells on Form EIA-23 “Annual Survey of Domestic Oil and Gas Reserves.” Of the 22,519 operators in the 2001 survey, 1,867 were included in the sample.
- all operators of active domestic natural gas processing plants who annually report their operations on Form EIA-64A “Annual Report of the Origin of Natural Gas Liquids Production.” For the 2001 survey, there were 525 active plants, all of which responded.

Only the largest oil and gas well operators (those producing 1.5 million barrels or more of crude oil or 15 billion cubic feet or more of natural gas, or both) are required to maintain and submit to EIA both proved reserves and production estimates by field for all of their operated properties. There were 172 large operators in the 2001 survey, all of which were included in the sample. Their response rate was 100 percent.

Intermediate size operators (those producing less than the largest operators but at least 400,000 barrels of crude oil, or at least 2 billion cubic feet of natural gas, or both) are required to submit production estimates by field for all of their operated properties, but are only required to submit proved reserves estimates by field when they maintain them in their records. There were 439 mid-sized operators in the 2001 survey. All were included in the sample and their response rate was also 100 percent.

Small operators are those with production less than the other limits. There were 21,908 small operators in the 2001 survey. Of these, 1,175 were sampled with certainty at an associated response rate of 98 percent and an additional 622 were randomly sampled at an associated response rate of 95 percent.

Because the EIA reserves survey is expressly designed to minimize the respondents’ reporting burden and yet provide highly reliable estimates at the State and National levels of data aggregation, the EIA does not have in its files operator-submitted, field-specific proved reserves information covering every oil or gas field in the country. For example:

- The EIA may have only partial reported proved reserves estimates for a field that has two or more operators, at least one of which is not required to report proved reserves by field.
- Especially for small fields, the EIA may not have any reported proved reserves estimates.

However, because the large and intermediate size operators tend to operate the larger fields, whereas the small operators are primarily active in the far more numerous small fields, the EIA does have in its files field-specific, operator-submitted proved reserves estimates covering about 90 percent of all estimated domestic proved reserves.

These types of deficiencies in the EIA's field-specific reserves information were satisfactorily remedied for this inventory by use of additional procedures based on either publicly available production data or reserve-to-production ratio analogs. The procedures used are detailed in Appendix 6.

Beyond the necessity to develop complete proved reserves estimates when complete operator-submitted estimates were lacking, there were two additional limitations:

(1) As collected in the EIA reserves survey, field location is at the county level. Attainment of the much more precise field locations required for this inventory's GIS-based methodology necessitated cross-correlation of the EIA's reserves data files with commercial sources of field and/or well information which provide far more precise field location data. This process involved much highly detailed, often well-by-well, work owing to the existence of non-standard field names and codes, or the occasional lack of a field name, in the commercial data sources.

(2) EIA is obligated by law to ensure the confidentiality of the data submitted by each reserves survey respondent. Within the EPCA study areas, there were many situations where a field was operated by a single operator or where one operator was heavily dominant. In such instances, EIA cannot disclose the proved reserves estimates for the field in absence of a written agreement in which the operator waives its right to confidentiality. Such agreements are exceedingly rare. Therefore, to avoid the release of confidential information while still adequately informing this inventory, EIA elected not to present field-specific proved reserves estimates even in instances where doing so would not have compromised a respondent's submission. Instead, the fields have uniformly been classified into a range of proved reserves categories that are broad enough to prevent extraction of the proved reserves estimates for any specific field. The resulting summary of proved reserves is shown in table 2b.

The proved oil and gas reserves are not mapped as are the undiscovered technically recoverable resources in figures 2i through 2r and figures 3l through 3ad. However, the reserves figures, presented in table 2b, are included in the summary tables and pie charts (table ES-1, figure ES-2, tables 3a through 3f and figures 3a through 3f). Proved reserves are included in the "Leasing, Standard Lease Terms (SLT)" category since by definition they are accessible with minimal constraints.

See Appendix 6 for a more detailed explanation of proved reserves estimation and field boundary construction.

Basin	Number of Fields	Total Liquid Reserves (Mbbbl)	Federal Land Liquid Reserves (Mbbbl)	% Federal	Total Gas Reserves (MMcf)	Federal Land Gas Reserves (MMcf)	% Federal	Total BOE* Reserves (Mbbbl)	Federal Land BOE Reserves (Mbbbl)	% Federal
<i>Paradox-San Juan</i>	250	174,193	53,103	30.5	20,653,622	11,033,357	53.4	3,616,464	1,891,996	52.3
<i>Uinta-Piceance</i>	180	254,329	142,495	56.0	7,181,669	3,779,755	52.6	1,451,274	772,454	53.2
<i>Greater Green River</i>	281	177,362	122,234	68.9	12,703,038	10,081,667	79.4	2,294,535	1,802,512	78.6
<i>Powder River</i>	543	193,456	110,783	57.3	2,398,604	927,738	38.7	593,223	265,406	44.7
<i>Montana Thrust Belt</i>	1	1	0	0.0	0	0	0.0	1	0	0.0
<b>Total</b>	<b>1,255</b>	<b>799,341</b>	<b>428,616</b>	<b>53.6</b>	<b>42,936,933</b>	<b>25,822,517</b>	<b>60.1</b>	<b>7,955,497</b>	<b>4,732,368</b>	<b>59.5</b>

\*Barrels of Oil Equivalent


**Table 2b** *Proved Reserves Summary Statistics, 2001*

## 2.4 DATA INTEGRATION AND SPATIAL ANALYSIS

Data integration and spatial analysis were performed as described below. The assumptions that were made as a part of the modeling process are described and the spatial analysis performed in the GIS are described in Appendix 7.

### 2.4.1 Categorization for Federal Land Status and Lease Stipulations

Two factors affect access to oil and gas resources on Federal lands: land status (Section 2.1.1) and leasing stipulations (Section 2.1.2). To simplify the analysis and present meaningful results, these two factors were combined into a hierarchy of categories that represents varying levels of access as shown in table 2c. This categorization was necessary to enable a reasonable quantitative analysis given the fact that approximately 1,000 unique stipulations exist within the study areas.

<p>More Constrained</p>  <p>Less Constrained</p>	Level	Access Category	Comments
	1.	No Leasing (Statutory/Executive Order), (NLS)	Status set by Law or Executive Order; drilling prohibited
	2.	No Leasing (Administrative), Pending Land Use Planning or NEPA Compliance (NLA/LUP)	Status set by Federal surface management agency; drilling prohibited
	3.	No Leasing (Administrative), general category (NLA)	
	4.	Leasing, No Surface Occupancy (NSO)	Directional drilling permitted from off-lease locations*
	5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months (TLs >9)	
	6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months (TLs 6-9)	
	7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months (TLs 3-6)	Categorized by the cumulative effect of seasonal leasing stipulations during which drilling is prohibited, generally for protection of wildlife
	8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months (TLs <3)	
	9.	Leasing, Controlled Surface Use (CSU)	Drilling permitted, specialized mitigation plan required
	10.	Leasing, Standard Lease Terms (SLTs)	Drilling permitted, mitigation plan required

\*Resources under margins of NSO areas may be accessible by directional drilling.

**Table 2c** *Categorization Hierarchy*

The hierarchy of categories was formulated to ensure that the potential for oil and gas development could be appropriately assessed (especially for areas of multiple, overlapping stipulations), and to ensure that the cumulative impacts on access would be examined. In addition, the hierarchy was formulated based upon the accessibility of the lands for leasing, for areas in which leasing is permitted, and the impacts relative to the costs to operators for conducting drilling.

The categorization is ordered from No Leasing to Leasing with Standard Lease Terms as follows:

1. **No Leasing (Statutory/Executive Order) (NLS)** are areas that cannot be leased due to Congressional or Presidential action. Examples include national parks, national monuments, and wilderness areas.
2. **No Leasing (Administrative) Pending Land Use Planning or NEPA Compliance (NLA/LUP)** are Federal administrative areas that are currently undergoing land use planning or NEPA analysis and are not currently available for leasing.<sup>5</sup> Table A7-1 in Appendix 7 shows the NLA/LUP jurisdictions within the EPCA inventory area.
3. **No Leasing (Administrative) (NLA)** are areas in which leasing does not occur based on discretionary decisions made by the Federal land management agency. NLAs include endangered species habitat and historical sites.
4. **Leasing, No Surface Occupancy (NSO)** are areas that can be leased but stipulations generally prohibit surface occupancy for natural gas and oil exploration and development activities to protect identified resources such as special status plant species habitat. NSO areas are treated in the analysis as no access areas (administrative); however, these areas can be accessed by directional drilling as described later in this document.
- 5-8. **Leasing, Cumulative Timing Limitations (TLs)** are areas that can be leased, but stipulations limit the time of the year when oil and gas exploration and drilling can take place. Timing limitation stipulations prohibit surface use during specified time intervals to protect identified resources such as sage grouse habitat or elk calving areas.
9. **Leasing, Controlled Surface Use (CSU)** are areas that can be leased, but stipulations control the surface location of natural gas and oil exploration and development activities by excluding them from certain portions of the lease. For example, a CSU stipulation could require an operator to develop a specialized mitigation plan based on the presence of steep slopes within a lease area.
10. **Leasing, Standard Lease Terms (SLT)** are areas that can be leased, and where no additional stipulations are added to the standard lease form. Standard lease terms, however, still dictate that the lessee comply with a number of environmentally protective and other requirements.

Appendix 9 (available on the CD-ROMs or the web sites) provides a listing and coding of the individual stipulations for each of the study areas.

## 2.4.2 Analytical Modeling of Federal Lands and Resources

See Appendix 7 for a detailed description of the GIS methodology used to categorize the Federal lands and resources for the inventory.

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<sup>5</sup> This category was determined on a case-by-case basis as the initiation of a new land use plan or plan revision does not generally preclude leasing under an existing plan.



## 3.0 RESULTS

The results of the analyses are presented below where they are summarized by access category for land area and resources. Table 3a shows the results for the combined study areas and Tables 3b through 3f show the results for individual study areas. These tables show the results for land access categorization for land area, total liquids (oil, NGLs and liquids associated with gas reservoirs), and total natural gas (associated and non-associated). Total liquids and total natural gas comprise undiscovered technically recoverable resources and proved reserves. Matching charts depicting the access categorization are shown in figures 3a through 3f. Federal land access categorization maps for each study area are shown in figures 3g through 3k.

Corresponding maps showing the accessibility of undiscovered liquids resources on Federal lands for each study area are shown in figures 3l through 3p. Maps showing the accessibility of undiscovered natural gas resources on Federal lands for each study area are shown in figures 3q through 3ad. Note that, by way of example, figures 3s through 3ab show the GGRB Study Area where, in a sequence of the ten maps, the undiscovered natural gas resources available at each of the land access hierarchy levels are presented. This represents a sample of what can be derived from the GIS data that can be found on the CD-ROM.

For the remainder of Section 3 the term “resources” is used to denote “undiscovered technically recoverable resources and proved reserves.”

### 3.1 STUDY AREA FEATURES

Each of the study areas is unique in terms of its Federal lands, resources and reserves accessibility. Noted features are presented below:

#### 3.1.1 Paradox/San Juan Basin

- Approximately 34 percent (5.96 million acres) of the Federal land in the basin is available for oil and gas leasing with standard stipulations (Figure 3b, “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 52 percent (224 million barrels) of the technically recoverable oil and 79 percent (28.9 trillion cubic feet) of the technically recoverable gas in the basin.
- Approximately 9 percent (1.62 million acres) of the Federal land is available for leasing with restrictions on oil and gas operations beyond standard stipulations (Figure 3b, all other “Leasing” categories except “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 16 percent (68 million barrels) of the technically recoverable oil and 17 percent (6.28 trillion cubic feet) of the technically recoverable gas in the basins.
- Approximately 57 percent (10 million acres) of the Federal land in the basin is not available for leasing (Figure 3b, 3 “No Leasing” categories). Based on resource estimates, these lands contain about 32 percent (138 million barrels) of the technically recoverable oil and 3 percent (1.18 trillion cubic feet) of the technically recoverable natural gas in the basins.
- The estimated volume of oil under all lands within the basin ranges from 174 to 1,319 million barrels, with a mean estimate of 660 million barrels<sup>1</sup>.

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<sup>1</sup>USGS reports the volume of undiscovered oil and natural using a range of likelihoods (or percentage) that a certain volume of oil and natural gas is present. These estimates range from a 5 percent chance for a

- The estimated volume of natural gas under all lands within the basin ranges from 41 to 64 trillion cubic feet, with a mean estimate of 52 trillion cubic feet.
- Most of the undiscovered natural gas (approximately 95 percent) is found widely dispersed in continuous<sup>2</sup> deposits rather than distinct structural traps.
- Most of the oil (52 percent) and natural gas (79 percent) are available under standard lease terms.
- Among the five study areas in the inventory, this area has the greatest proportion of proved natural gas reserves (28 percent) relative to undiscovered resources.

### 3.1.2 Uinta/Piceance Basin

- Approximately 45 percent (6.23 million acres) of the Federal land in the basin is available for oil and gas leasing with standard stipulations (Figure 3c, “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 85 percent (186 million barrels) of the technically recoverable oil and 57 percent (9.26 trillion cubic feet) of the technically recoverable gas in the basin.
- Approximately 35 percent (4.74 million acres) of the Federal land is available for leasing with restrictions on oil and gas operations beyond standard stipulations (Figure 3c, all other “Leasing” categories except “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 9 percent (19 million barrels) of the technically recoverable oil and 37 percent (5.99 trillion cubic feet) of the technically recoverable gas in the basins.
- Approximately 20 percent (2.72 million acres) of the Federal land in the basin is not available for leasing (Figure 3c, 3 “No Leasing” categories). Based on resource estimates, these lands contain about 7 percent (14 million barrels) of the technically recoverable oil and 6 percent (0.89 trillion cubic feet) of the technically recoverable natural gas in the basins.
- The estimated volume of oil under all lands within the basin ranges from 61 to 296 million barrels, with a mean estimate of 149 million barrels.
- The estimated volume of natural gas under all lands within the basin ranges from 12 to 35 trillion cubic feet, with a mean estimate of 22 trillion cubic feet.
- Most of the undiscovered natural gas (greater than 95 percent) is found widely dispersed in continuous deposits rather than distinct structural traps.
- Among the five study areas, this area has the highest percentage of oil (85 percent) available under standard lease terms. This is partly because most of the oil (63 percent) is proved reserves.
- Compared to the other four areas in this inventory, this area has the highest percentage of federal lands (9 percent), as well as the natural gas (15 percent) resources designated within the “no surface occupancy” category.

### 3.1.3 Greater Green River Basin

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large volume to a 95 percent chance for a small volume of oil and natural gas to occur. This inventory used the mean or the average of all the possible likelihoods and volumes. For the Paradox/San Juan Basin, there is a 5 percent likelihood that 1,319 million barrels of oil and a 95 percent likelihood that 174 million barrels of oil could occur. However, the average estimate for the area is 600 million barrels of oil.

<sup>2</sup> A continuous accumulation of oil or natural gas is one that is located throughout a large area and lacks a discrete border or structural trap.

- Approximately 45 percent (5.12 million acres) of the Federal land in the basin is available for oil and gas leasing with standard stipulations (Figure 3d, “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 57 percent (1,162 million barrels) of the technically recoverable oil and 61 percent (43.6 trillion cubic feet) of the technically recoverable gas in the basin.
- Approximately 37 percent (4.24 million acres) of the Federal land is available for leasing with restrictions on oil and gas operations beyond standard stipulations (Figure 3d, all other “Leasing” categories except “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 31 percent (635 million barrels) of the technically recoverable oil and 29 percent (20.6 trillion cubic feet) of the technically recoverable gas in the basins.
- Approximately 19 percent (2.16 million acres) of the Federal land in the basin is not available for leasing (Figure 3d, 3 “No Leasing” categories). Based on resource estimates, these lands contain about 13 percent (259 million barrels) of the technically recoverable oil and 10 percent (7.35 trillion cubic feet) of the technically recoverable natural gas in the basins.
- The estimated volume of oil under all lands within the basin ranges from 1,367 to 4,724 million barrels, with a mean estimate of 2,709 million barrels.
- The estimated volume of natural gas under all lands within the basin ranges from 53 to 127 trillion cubic feet, with a mean estimate of 85 trillion cubic feet.
- Almost all of the undiscovered natural gas (97 percent) is widely dispersed in continuous deposits rather than distinct structural traps.
- A relatively large portion of the federal land (29 percent of the surface area) and, 27 percent of the oil and 25 percent of the natural gas are under timing limitations of 3 to 9 months.
- Among the five inventory areas, this area has the greatest volume of oil (2.1 billion barrels) and natural gas (72 trillion cubic feet) under federal lands.
- The land ownership pattern is highly complex due a checkerboard pattern of ownership resulting from railroad grants.

### 3.1.4 Powder River Basin

- Approximately 52 percent (5.51 million acres) of the Federal land in the basin is available for oil and gas leasing with standard stipulations (Figure 3e, “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 63 percent (620 million barrels) of the technically recoverable oil and 59 percent (4.82 trillion cubic feet) of the technically recoverable gas in the basin.
- Approximately 35 percent (3.73 million acres) of the Federal land is available for leasing with restrictions on oil and gas operations beyond standard stipulations (Figure 3e, all other “Leasing” categories except “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 33 percent (324 million barrels) of the technically recoverable oil and 32 percent (2.57 trillion cubic feet) of the technically recoverable gas in the basins.
- Approximately 14 percent (1.45 million acres) of the Federal land in the basin is not available for leasing (Figure 3e, 3 “No Leasing” categories). Based on resource estimates, these lands contain about 4 percent (36 million barrels) of the technically recoverable oil and 9 percent (0.76 trillion cubic feet) of the technically recoverable natural gas in the basins.

- The estimated volume of oil under all lands within the basin ranges from 350 to 3,345 million barrels, with a mean estimate of 1,642 million barrels.
- The estimated volume of natural gas under all lands within the basin ranges from 9 to 27 trillion cubic feet, with a mean estimate of 16 trillion cubic feet.
- Almost all undiscovered natural gas is continuous coalbed natural gas (98 percent).
- Most of the federal land (52 percent) and 63 percent of the oil and 59 percent of the natural gas are available under standard lease terms.
- Among the five inventory areas, this area has the highest proportion of federal land (10 percent) and 12 percent of the oil, and 11 percent of the natural gas available under the controlled surface use category.
- Among the five inventory areas, this area has the highest proportion of split estate lands<sup>3</sup> (60 percent of federal lands).

### 3.1.5 Montana Thrust Belt

- Approximately 4 percent (0.23 million acres) of the Federal land in the basin is available for oil and gas leasing with standard stipulations (Figure 3f, “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 3 percent (6 million barrels) of the technically recoverable oil and 1 percent (0.05 trillion cubic feet) of the technically recoverable gas in the basin.
- Approximately 14 percent (0.83 million acres) of the Federal land is available for leasing with restrictions on oil and gas operations beyond standard stipulations (Figure 3f, all other “Leasing” categories except “Leasing, Standard Lease Terms”). Based on resource estimates, these lands contain 9 percent (15 million barrels) of the technically recoverable oil and 8 percent (0.52 trillion cubic feet) of the technically recoverable gas in the basins.
- Approximately 82 percent (4.79 million acres) of the Federal land in the basin is not available for leasing (Figure 3f, 3 “No Leasing” categories). Based on resource estimates, these lands contain about 88 percent (149 million barrels) of the technically recoverable oil and 91 percent (5.73 trillion cubic feet) of the technically recoverable natural gas in the basins.
- The estimated volume of oil under all lands within the area ranges from 55 to 843 million barrels, with a mean estimate of 348 million barrels.
- The estimated volume of natural gas under all lands within the area ranges from 1.1 to 21 trillion cubic feet, with a mean estimate of 8.6 trillion cubic feet.
- The area contains the smallest volume of resource of all five-inventory areas (oil, 348 million barrels; natural gas, 8.6 trillion cubic feet).
- A high percentage of the federal land (82 percent) and 88 percent of the oil and 91 percent of the natural gas are currently “closed” to leasing.
- The USDA-Forest Service is the primary federal land manager in the area (69 percent of the area of which almost half is currently “closed” to leasing while undergoing new land use planning).

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<sup>3</sup> Split estate lands are those lands where the surface rights belong to private individuals but the subsurface mineral rights are publicly held, and managed by the federal government.

Level	Access Category	Area		Resources			
		(acres x1000)	Percent of Federal	Total Liquids* (MMBbl)***	Percent of Federal	Total Natural Gas** (Bcf)****	
1.	No Leasing (Statutory/Executive Order)	10,068	17%	298	8%	9,035	7%
2.	No Leasing (Administrative, Pending Land Use Plan)	6,007	10%	116	3%	3,690	3%
3.	No Leasing (Administrative)	5,098	9%	182	5%	3,185	2%
4.	Leasing, No Surface Occupancy	2,714	5%	50	1%	3,120	2%
5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months	25	0%	3	0%	114	0%
6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months	2,521	4%	250	6%	5,549	4%
7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months	5,442	9%	528	14%	20,401	15%
8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months	697	1%	8	0%	733	1%
9.	Leasing, Controlled Surface Use	3,753	6%	221	6%	6,080	4%
10.	Leasing, Standard Lease Terms	23,091	39%	2,198	57%	86,566	63%
Total, Federal Lands Including Split Estate		59,416	100%	3,854	100%	138,472	100%
Total Non-Federal		44,256		2,455		87,668	
Total Study Area		103,672		6,309		226,141	

\* Comprising oil, NGLs and liquids associated with natural gas reservoirs

\*\* Comprising associated dissolved and nonassociated natural gas

\*\*\*MMBbl -- Millions of Barrels

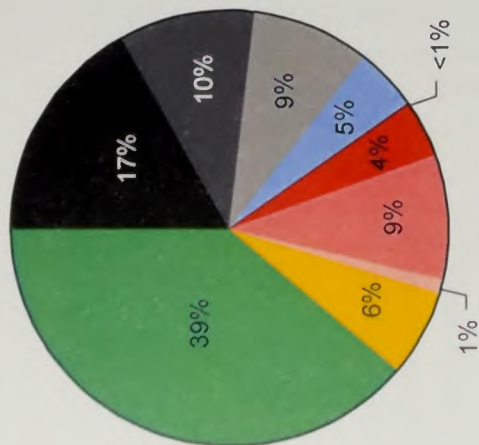
\*\*\*\*Bcf -- Billion cubic feet

Small rounding errors may be present

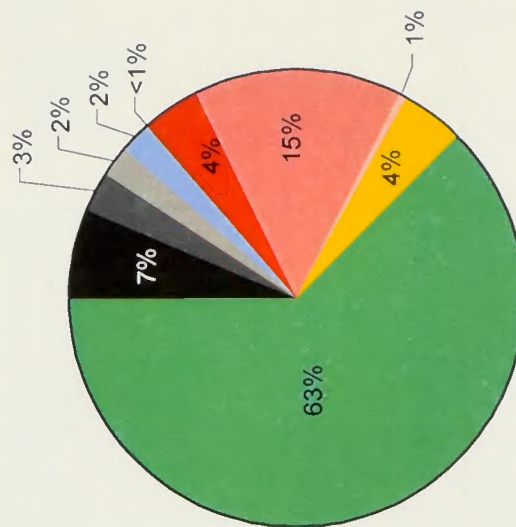
Closed to leasing	21,173	36%	596	15%	15,910	11%
Leasing with restrictions	15,152	26%	1,060	28%	35,997	26%
Leasing with standard lease terms	23,091	39%	2,198	57%	86,566	63%

Table 3a Summary of All EPCA Inventory Areas – Oil and Natural Gas Resources Affected by Access Categories

Percent of Federal and Split Estate Lands



Percent of Natural Gas Resources



Percent of Oil Resources

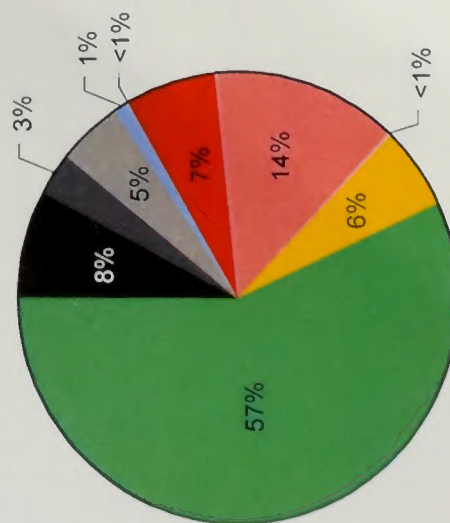


Figure 3a Summary of All EPCA Inventory Areas – Oil and Natural Gas Resources Affected by Access Categories

Level	Access Category	Area		Resources		
		(acres x1000)	Percent of Federal	Total Liquids* (MMBbl)***	Percent of Federal	Total Natural Gas** (Bcf)****
1.	No Leasing (Statutory/Executive Order), (NLS)	5,309	30%	66	15%	540
2.	No Leasing (Administrative), (NLA/LUP)	2,050	12%	4	1%	1
3.	No Leasing (Administrative), (NLA)	2,690	15%	68	16%	647
4.	Leasing, No Surface Occupancy (NSO)	196	1%	6	1%	67
5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months (TLs >9)	0	0%	0	0%	0
6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months (TLs 6-9)	95	1%	4	1%	402
7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months (TLs 3-6)	764	4%	33	8%	4,015
8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months (TLs <3)	23	0%	1	0%	10
9.	Leasing, Controlled Surface Use (CSU)	542	3%	23	5%	1,789
10.	Leasing, Standard Lease Terms (SLTs)	5,960	34%	224	52%	28,869
Total, Federal Lands Including Split Estate		17,628	100%	430	100%	36,340
Total Non-Federal		11,040		404		36,142
Total Study Area		28,669		834		72,482

\* Comprising oil, NGLs and liquids associated with natural gas reservoirs

\*\* Comprising associated dissolved and nonassociated natural gas

\*\*\*MMBbl -- Millions of Barrels

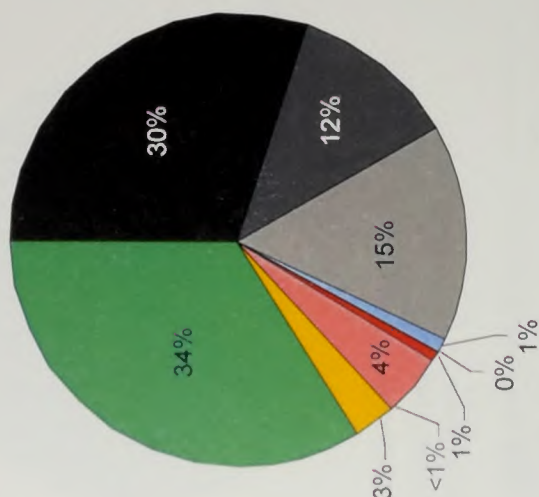
\*\*\*\*Bcf -- Billion cubic feet

Closed to leasing	10,048	57%	138	32%	1,187	3%
Leasing with restrictions	1,620	9%	68	16%	6,283	17%
Leasing with standard lease terms	5,960	34%	224	52%	28,869	79%

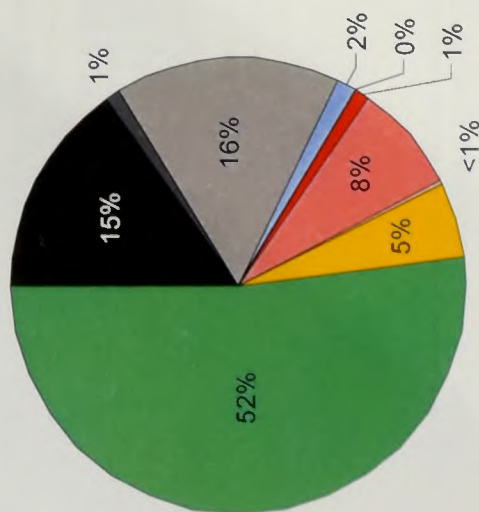
Table 3b

Results—Land and Resources Categorization, Paradox/San Juan Study Areas

Percent of Federal and Split Estate Lands



Percent of Oil Resources



Percent of Natural Gas Resources

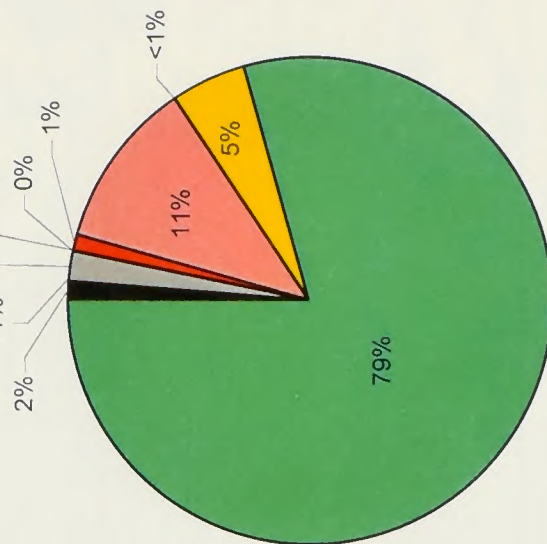


Figure 3b  
Chart of Results—Land and Resources Categorization, Paradox/San Juan Study Area

Level	Access Category	Area		Resources	
		(acres x1000)	Percent of Federal	Total Liquids* (MMBbl)***	Total Natural Gas** (Bcf)****
1.	No Leasing (Statutory/Executive Order), (NLS)	1,661	12.1%	13	661
2.	No Leasing (Administrative), (NLA/LUP)	644	4.7%	1	149
3.	No Leasing (Administrative), (NLA)	419	3.1%	0	81
4.	Leasing, No Surface Occupancy (NSO)	1,268	9.3%	8	2,433
5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months (TLs >9)	0	0.0%	0	0
6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months (TLs 6-9)	238	1.7%	1	86
7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months (TLs 3-6)	1,314	9.6%	4	1,652
8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months (TLs <3)	538	3.9%	2	585
9.	Leasing, Controlled Surface Use (CSU)	1,381	10.1%	4	1,232
10.	Leasing, Standard Lease Terms (SLTs)	6,231	45.5%	186	9,255
Total, Federal Lands Including Split Estate		13,694	100.0%	220	16,135
Total Non-Federal		5,252		184	12,708
Total Study Area		18,945		404	28,843

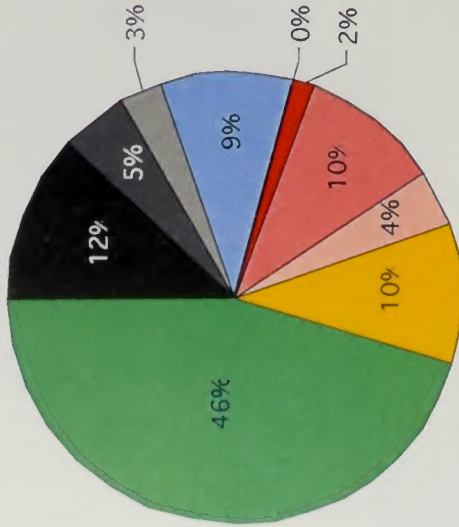
\* including oil, NGLs and liquids associated with natural gas reservoirs  
 \*\* including associated dissolved and nonassociated natural gas

\*\*\*MMBbl -- Millions of Barrels  
 \*\*\*\*Bcf -- Billion cubic feet

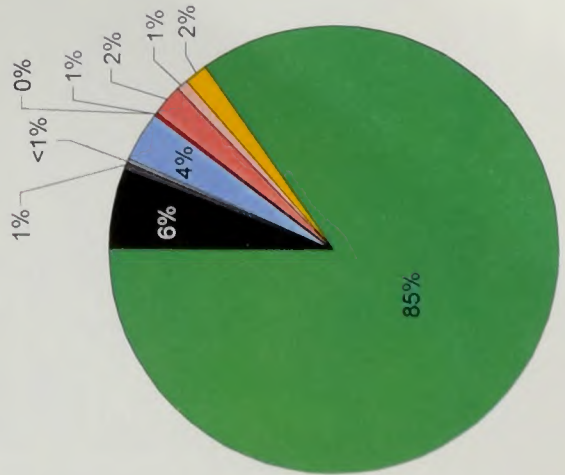
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Table 3c Results--Land and Resources Categorization, Uinta/Piceance Study Area

Percent of Federal and Split Estate Lands



Percent of Oil Resources



- No Leasing (Statutory/Executive Order)
- No Leasing (Administrative, Pending Land Use Plan)
- No Leasing (Administrative)
- Leasing, No Surface Occupancy
- Leasing, Cumulative Timing Limitations on Drilling >9 Months
- Leasing, Cumulative Timing Limitations on Drilling 6-9 Months
- Leasing, Cumulative Timing Limitations on Drilling 3-6 Months
- Leasing, Cumulative Timing Limitations on Drilling <3 Months
- Leasing, Controlled Surface Use
- Leasing, Standard Lease Terms

Percent of Natural Gas Resources

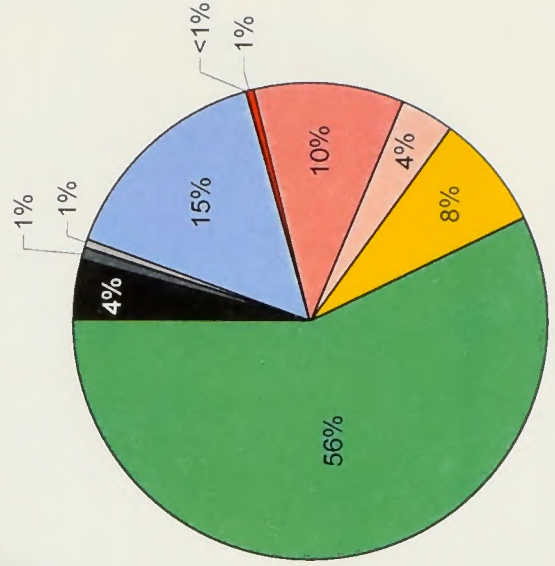


Figure 3c Chart of Results—Land and Resources Categorization, Uinta/Piceance Study Area

Level	Access Category	Area		Resources		
		(acres x1000)	Percent of Federal	Total Liquids* (MMBbl)***	Percent of Federal	Total Natural Gas** (Bcf)****
1.	No Leasing (Statutory/Executive Order), (NLS)	638	5.5%	135	6.6%	4,598
2.	No Leasing (Administrative), (NLA/LUP)	461	4.0%	37	1.8%	702
3.	No Leasing (Administrative), (NLA)	1,058	9.2%	86	4.2%	2,046
4.	Leasing, No Surface Occupancy (NSO)	266	2.3%	12	0.6%	175
5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months (TLs >9)	8	0.1%	3	0.1%	107
6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months (TLs 6-9)	992	8.6%	110	5.3%	4,055
7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months (TLs 3-6)	2,369	20.5%	437	21.3%	14,117
8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months (TLs <3)	64	0.6%	4	0.2%	104
9.	Leasing, Controlled Surface Use (CSU)	536	4.6%	69	3.4%	2,076
10.	Leasing, Standard Lease Terms (SLTs)	5,159	44.7%	1,162	56.5%	43,565
Total, Federal Lands Including Split Estate		11,551	100.0%	2,055	100.0%	71,546
Total Non-Federal		5,033		832		25,747
Total Study Area		16,583		2,887		97,293

\* including oil, NGLs and liquids associated with natural gas reservoirs

\*\* including associated dissolved and nonassociated natural gas

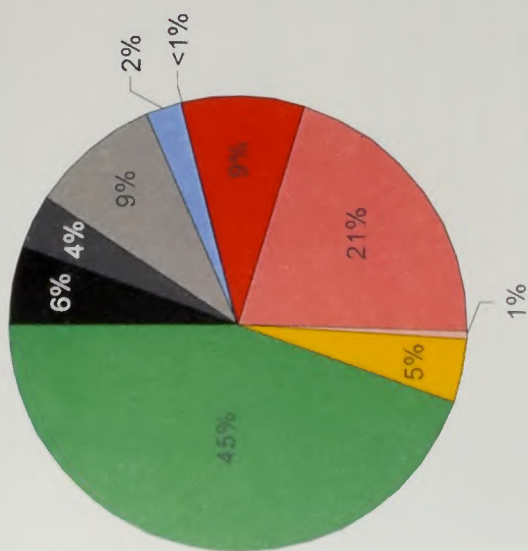
\*\*\*MMBbl -- Millions of Barrels

\*\*\*\*Bcf -- Billion cubic feet

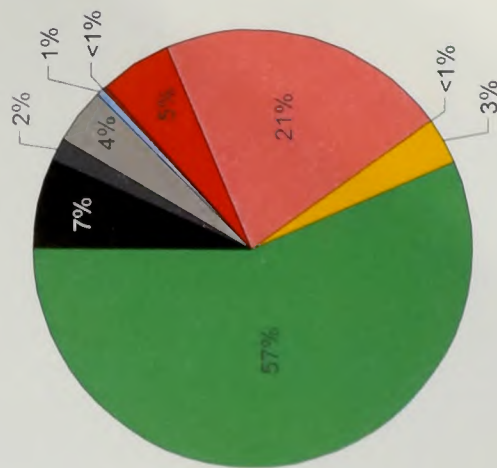
Small rounding errors  
may be present

Table 3d Results—Land and Resources Categorization, Greater Green River Study Area

Percent of Federal and Split Estate Lands



Percent of Oil Resources



Percent of Natural Gas Resources

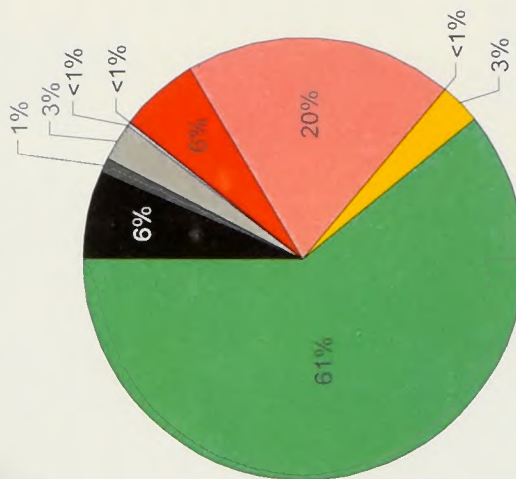


Figure 3d Chart of Results—Land and Resources Categorization, Greater Green River Study Area

Table 3e. Results—Land and Resources Categorization, Powder River Study Area

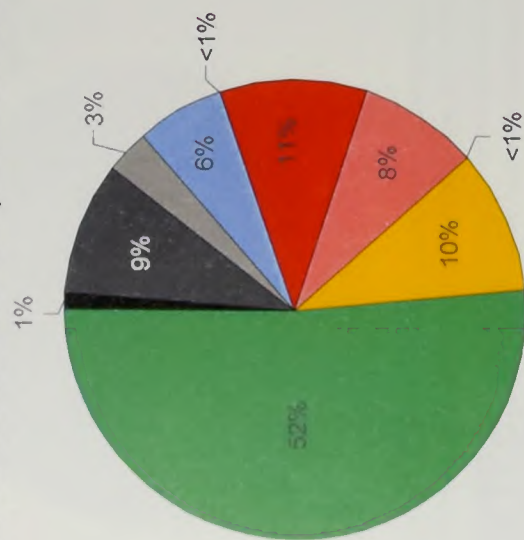
Level	Access Category	Area		Resources		
		(acres x1000)	Percent of Federal	Total Liquids* (MMBbl)***	Percent of Federal	Total Natural Gas** (Bcf)****
1.	No Leasing (Statutory/Executive Order), (NLS)	109	1%	0	0.0%	26
2.	No Leasing (Administrative), (NLA/LUP)	1,006	9%	17	1.7%	570
3.	No Leasing (Administrative), (NLA)	335	3%	18	1.9%	165
4.	Leasing, No Surface Occupancy (NSO)	644	6%	17	1.7%	178
5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months (TLs >9)	1	0%	0	0.0%	1
6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months (TLs 6-9)	1,122	10%	133	13.6%	961
7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months (TLs 3-6)	870	8%	52	5.3%	545
8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months (TLs <3)	3	0%	1	0.1%	4
9.	Leasing, Controlled Surface Use (CSU)	1,092	10%	121	12.4%	884
10.	Leasing, Standard Lease Terms (SLTs)	5,511	52%	620	63.3%	4,824
Total, Federal Lands Including Split Estate		10,693	100%	979	100%	8,157
Total Non-Federal		17,102		856		10,728
Total Study Area		27,796		1,835		18,885

\* Comprising oil, NGLs and liquids associated with natural gas reservoirs  
\*\* Comprising associated dissolved and nonassociated natural gas

\*\*\*MMBbl -- Millions of Barrels  
\*\*\*\*Bcf -- Billion cubic feet

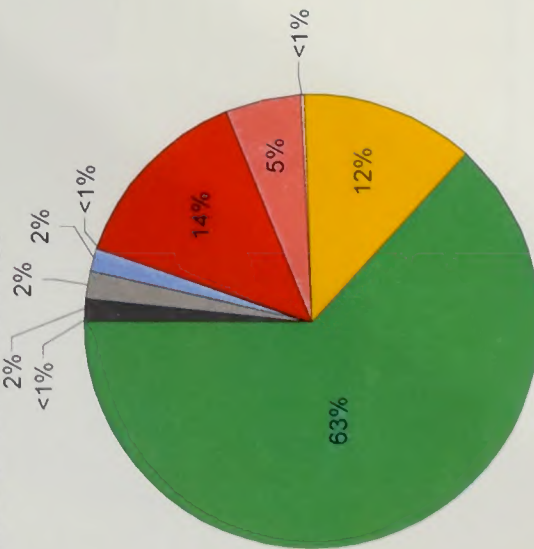
Closed to leasing	1,450	14%	36	4%	761	9%
Leasing with restrictions	3,733	35%	324	33%	2,572	32%
Leasing with standard lease terms	5,511	52%	620	63%	4,824	59%

Percent of Federal and Split Estate Lands



- No Leasing (Statutory/Executive Order)
- No Leasing (Administrative, Pending Land Use Plan)
- No Leasing (Administrative)
- Leasing, No Surface Occupancy
- Leasing, Cumulative Timing Limitations on Drilling >9 Months
- Leasing, Cumulative Timing Limitations on Drilling 6-9 Months
- Leasing, Cumulative Timing Limitations on Drilling 3-6 Months
- Leasing, Cumulative Timing Limitations on Drilling <3 Months
- Leasing, Controlled Surface Use
- Leasing, Standard Lease Terms

Percent of Oil Resources



Percent of Natural Gas Resources

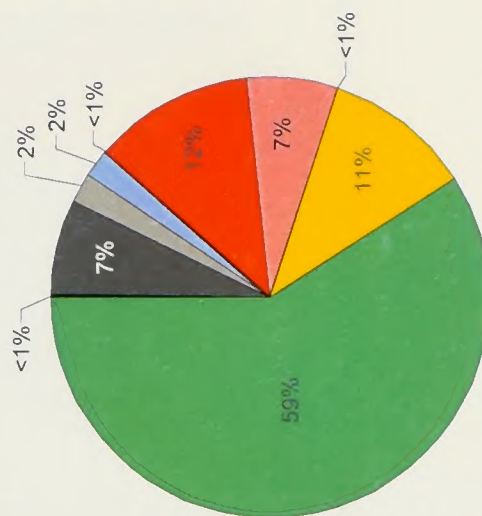


Figure 3e.

Chart of Results—Land and Resources Categorization, Powder River Study Area

Level	Access Category	Area		Resources		
		(acres x1000)	Percent of Federal	Total Liquids* (MMBbl)***	Percent of Federal	Total Natural Gas** (Bcf)****
1.	No Leasing (Statutory/Executive Order), (NLS)	2,351	40.2%	83	49.2%	3,210
2.	No Leasing (Administrative), (NLA/LUP)	1,846	31.6%	57	33.4%	2,269
3.	No Leasing (Administrative), (NLA)	597	10.2%	9	5.2%	247
4.	Leasing, No Surface Occupancy (NSO)	340	5.8%	7	3.9%	266
5.	Leasing, Cumulative Timing Limitations on Drilling >9 Months (TLs >9)	16	0.3%	0	0.1%	6
6.	Leasing, Cumulative Timing Limitations on Drilling 6-9 Months (TLs 6-9)	74	1.3%	1	0.6%	45
7.	Leasing, Cumulative Timing Limitations on Drilling 3-6 Months (TLs 3-6)	124	2.1%	3	1.5%	72
8.	Leasing, Cumulative Timing Limitations on Drilling <3 Months (TLs <3)	69	1.2%	1	0.4%	29
9.	Leasing, Controlled Surface Use (CSU)	203	3.5%	4	2.3%	99
10.	Leasing, Standard Lease Terms (SLTs)	230	3.9%	6	3.4%	52
Total, Federal Lands Including Split Estate		5,849	100.0%	170	100.0%	6,294
Total Non-Federal		5,829		179		2,344
Total Study Area		11,678		348		8,638

\* including oil, NGLs and liquids associated with natural gas reservoirs

\*\* including associated dissolved and nonassociated natural gas

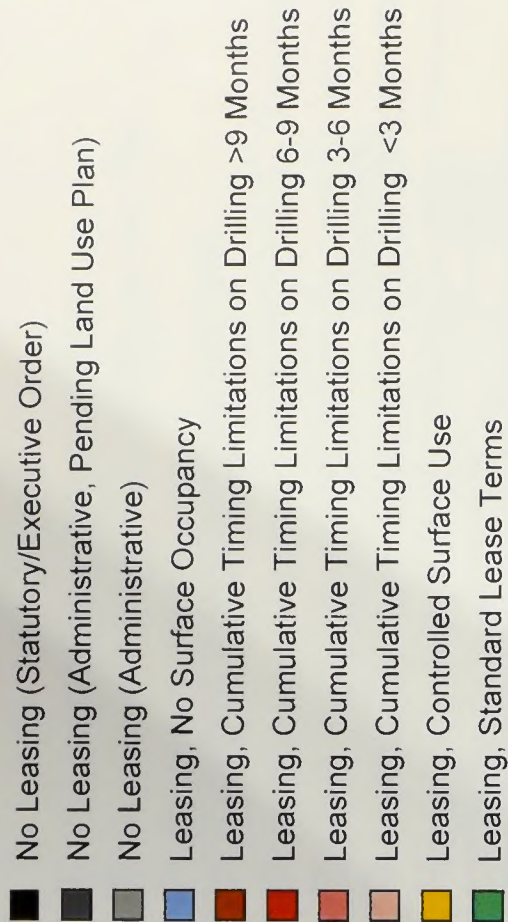
\*\*\*MMBbl -- Millions of Barrels

\*\*\*\*Bcf -- Billion cubic feet

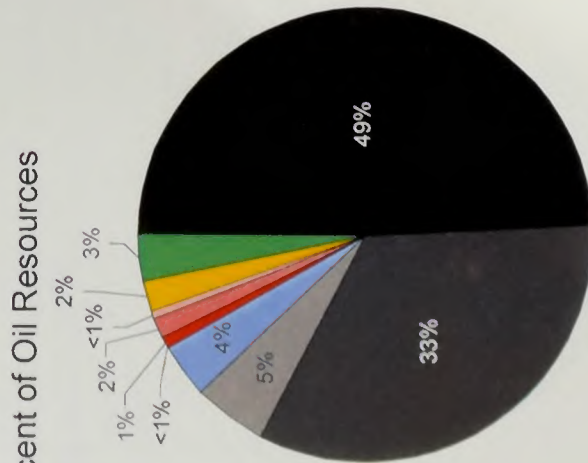
Small rounding errors  
may be present

Table 3f. Results--Land and Resources Categorization, Montana Thrust Belt Study Area

Percent of Federal and Split Estate Lands



Percent of Oil Resources



Percent of Natural Gas Resources

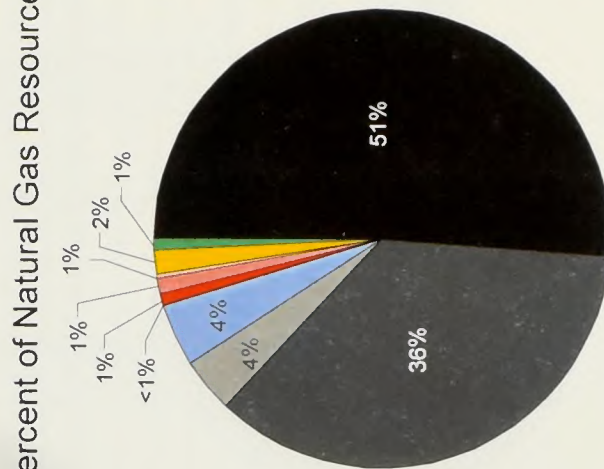
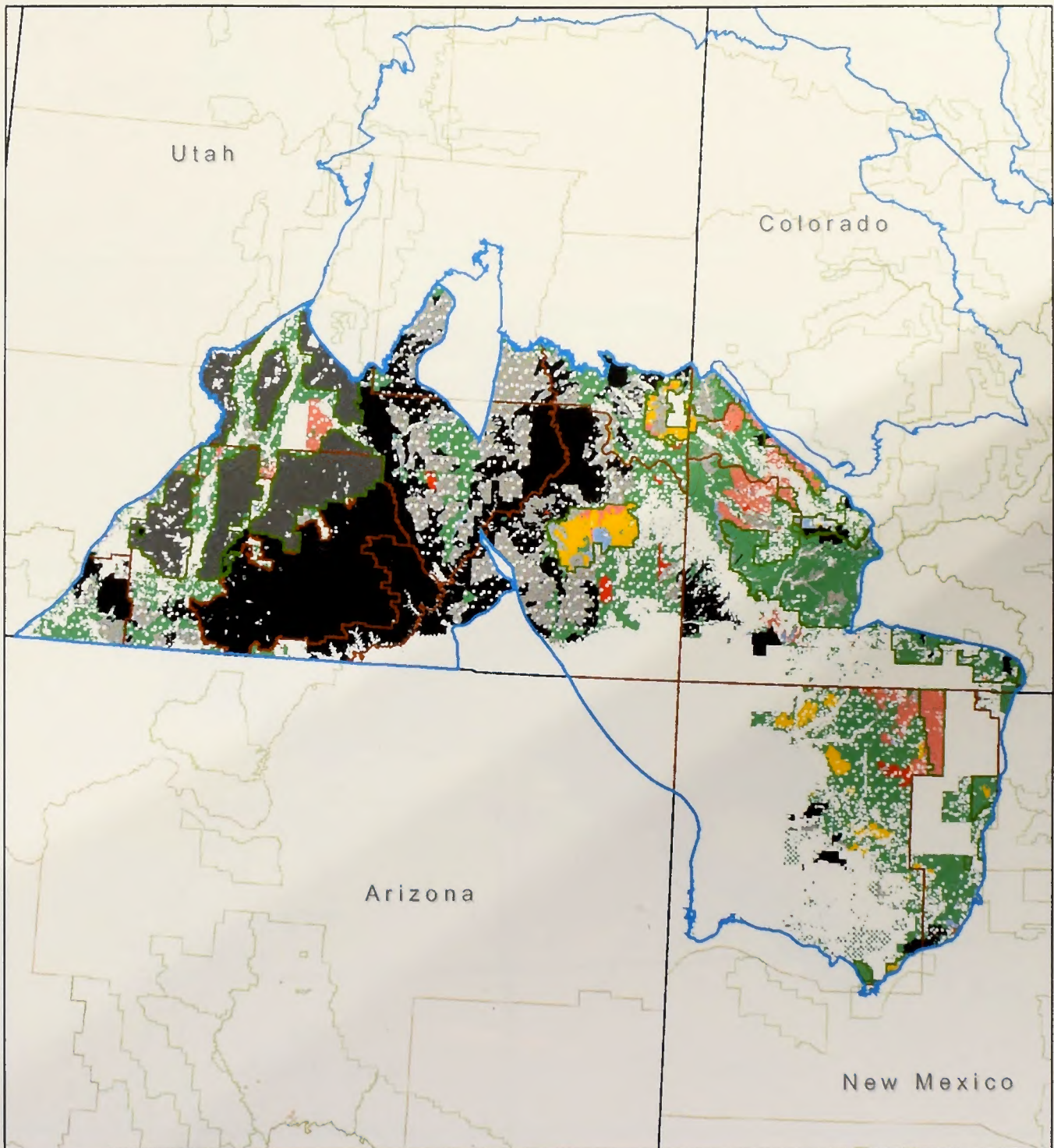
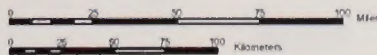


Figure 3f.

Chart of Results—Land and Resources Categorization, Montana Thrust Belt Study Area



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



USGS  
United States Geological Survey



USDA  
United States Department of Agriculture



USACE  
United States Army Corps of Engineers



EIA  
Environmental Impact Assessment

Access Categorization	
No Leasing (Statutory/Executive Order)	
No Leasing (Administrative/Land Use Planning)	
No Leasing (Administrative)	
No Surface Occupancy	
Timing Limitations > 9 Months	
Timing Limitations > 6 Months	
Timing Limitations < 3 months	
Controlled Surface Use	
Standard Lease Terms	

Figure 3g

Land Access Categorization Map – Paradox/San Juan Study Areas

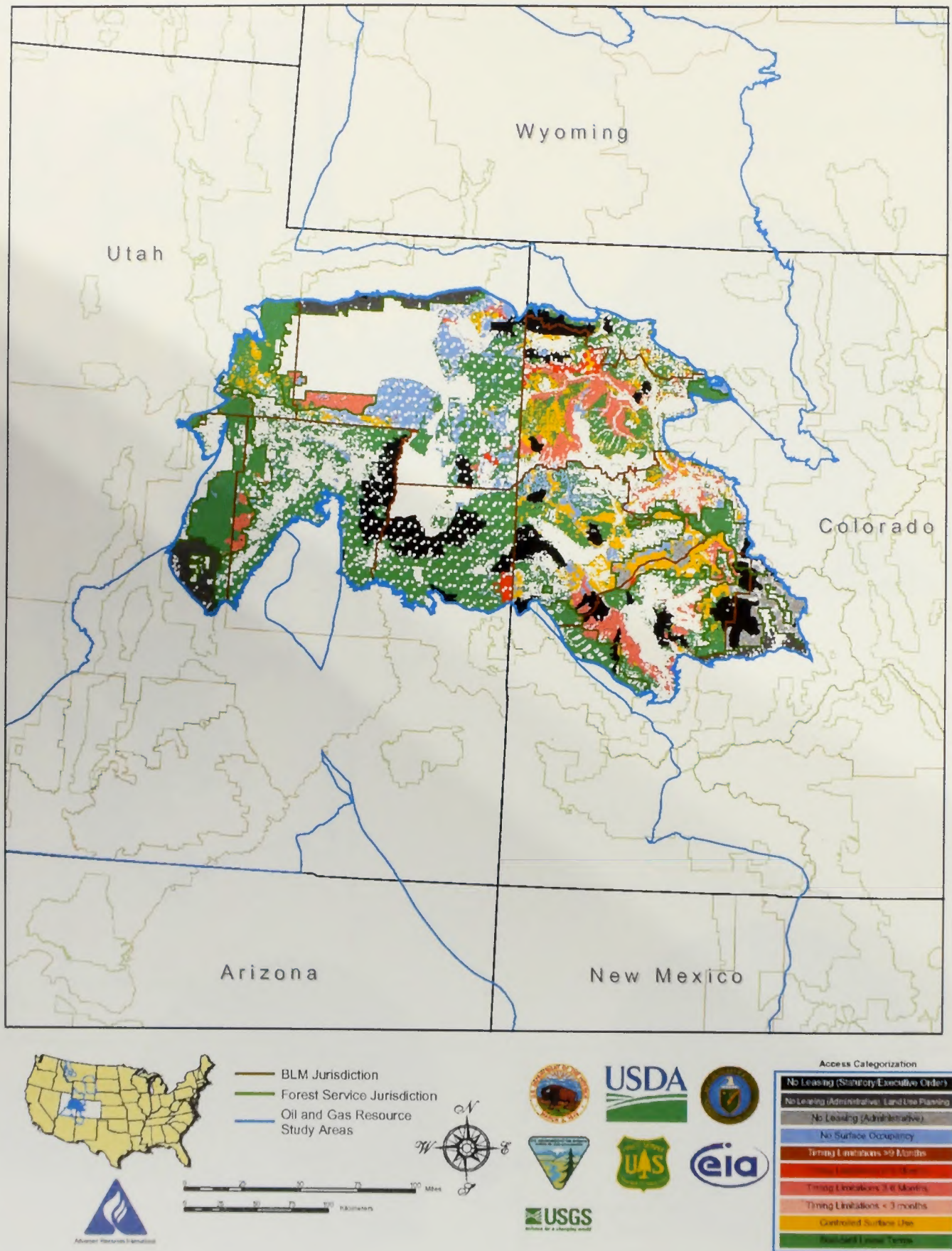
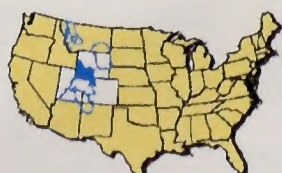
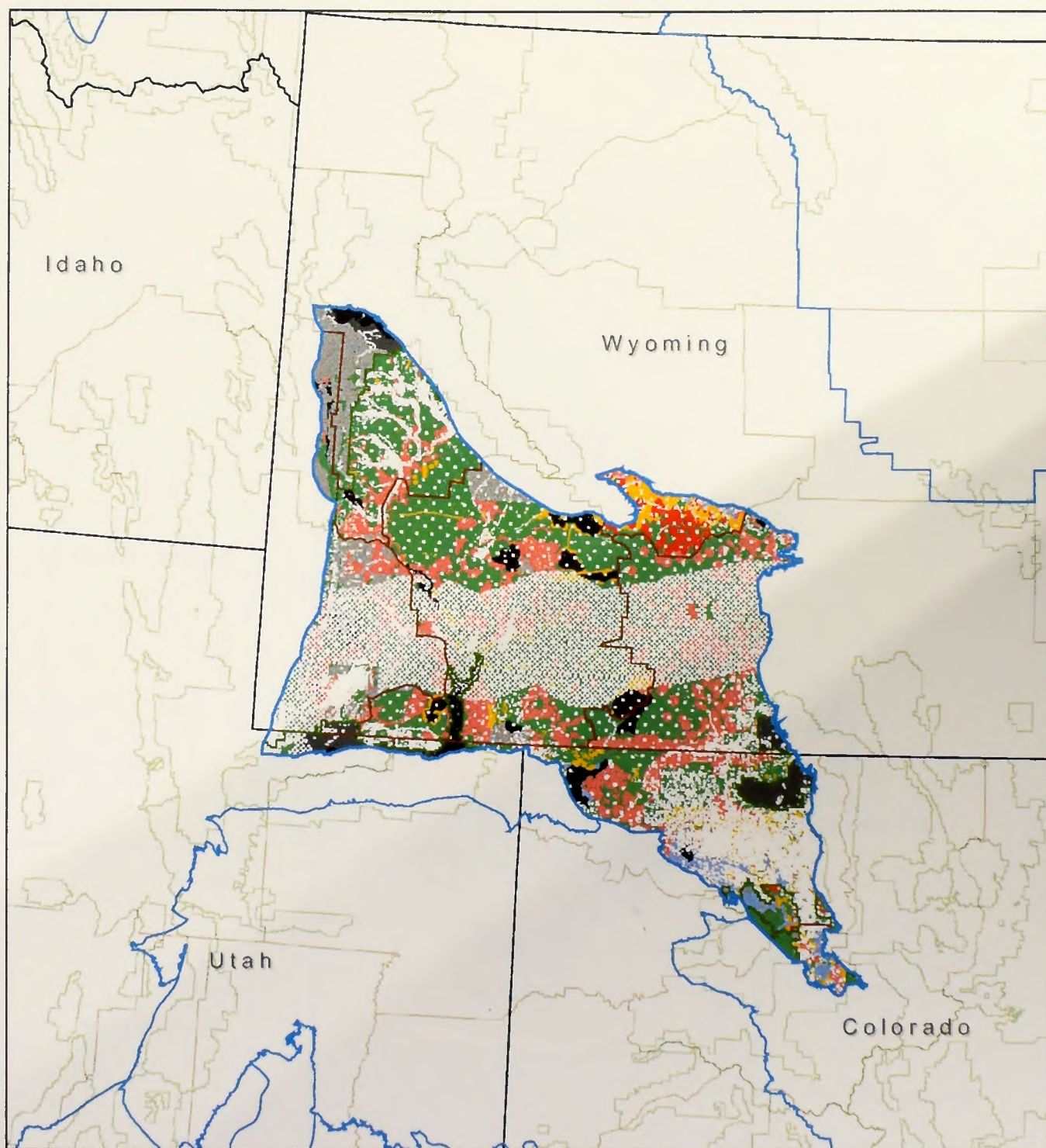
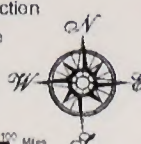


Figure 3h Land Access Categorization – Uinta/Piceance Study Areas



— BLM Jurisdiction  
— Forest Service Jurisdiction  
— Oil and Gas Resource Study Areas



Access Categorization	
No Leasing (Statutory/Executive Order)	
No Leasing (Administrative) Land Use Planning	
No Leasing (Administrative)	
No Surface Occupancy	
Timing Limitations > 9 Months	
Timing Limitations > 6 Months	
Timing Limitations 3-6 Months	
Timing Limitations < 3 months	
Controlled Surface Use	
Standard Lease Terms	

Figure 3i

Land Access Categorization – Greater Green River Study Area

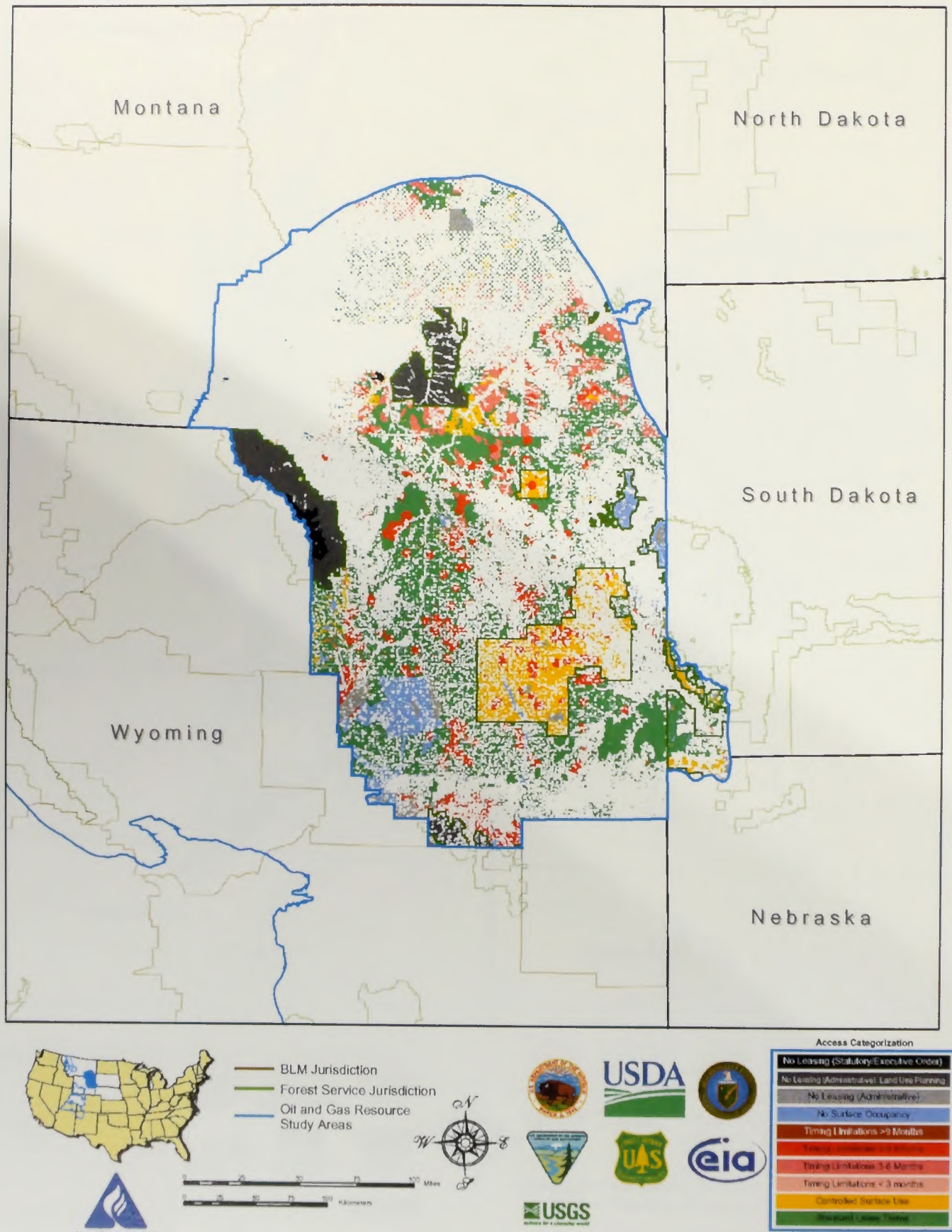


Figure 3j Land Access Categorization – Powder River Study Area

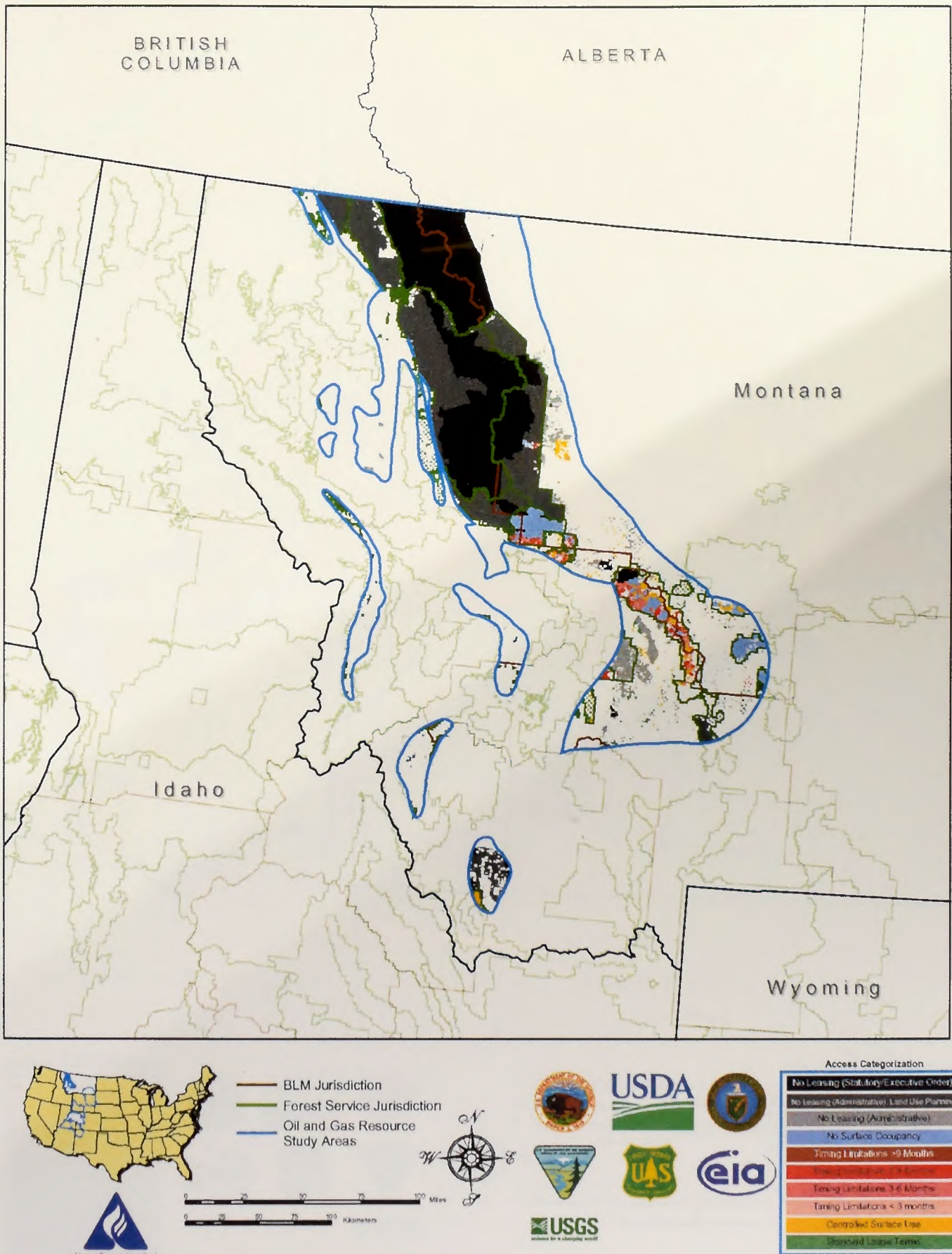
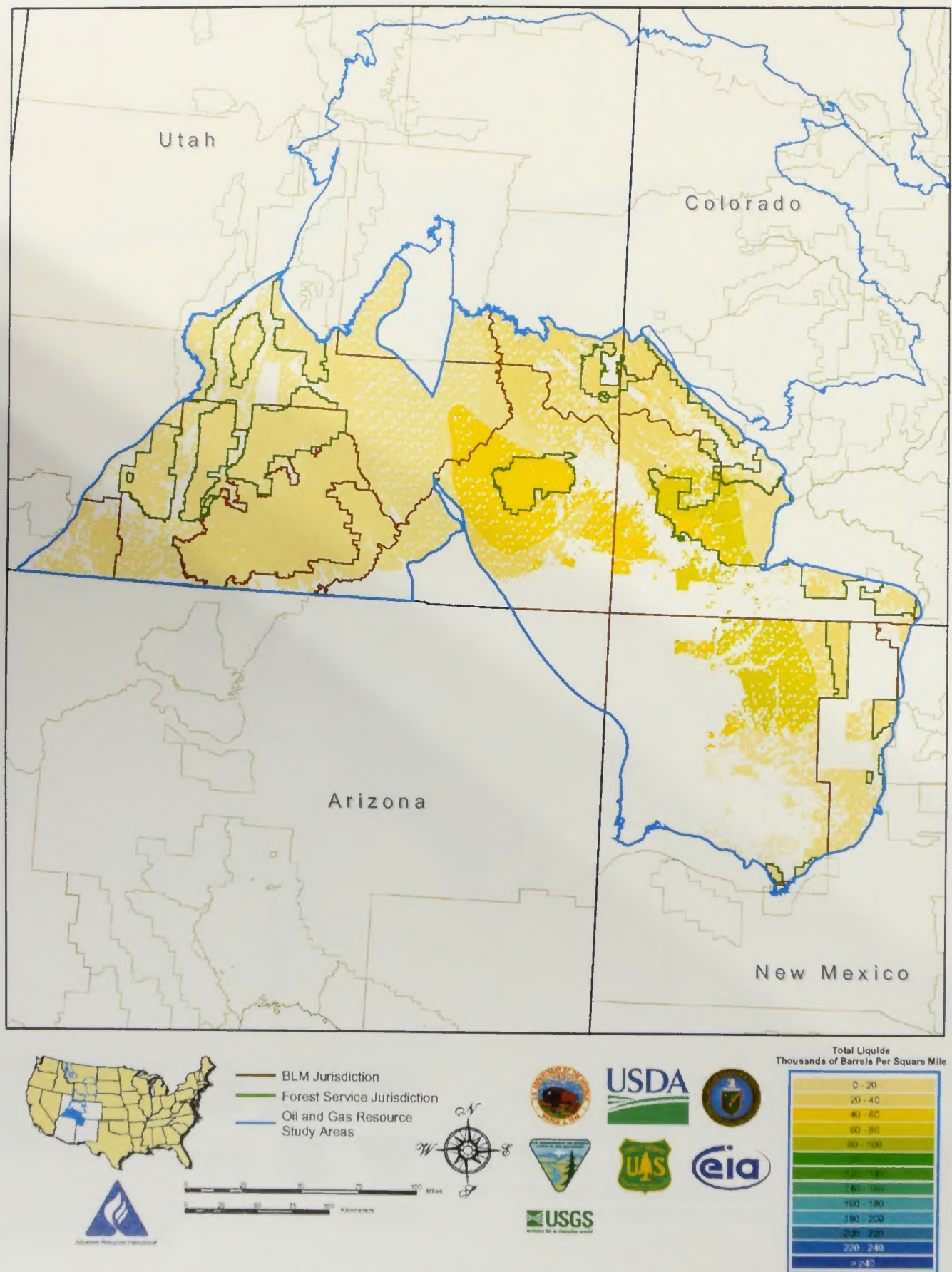
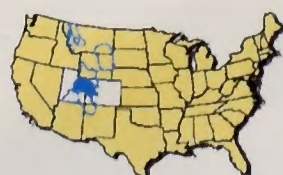
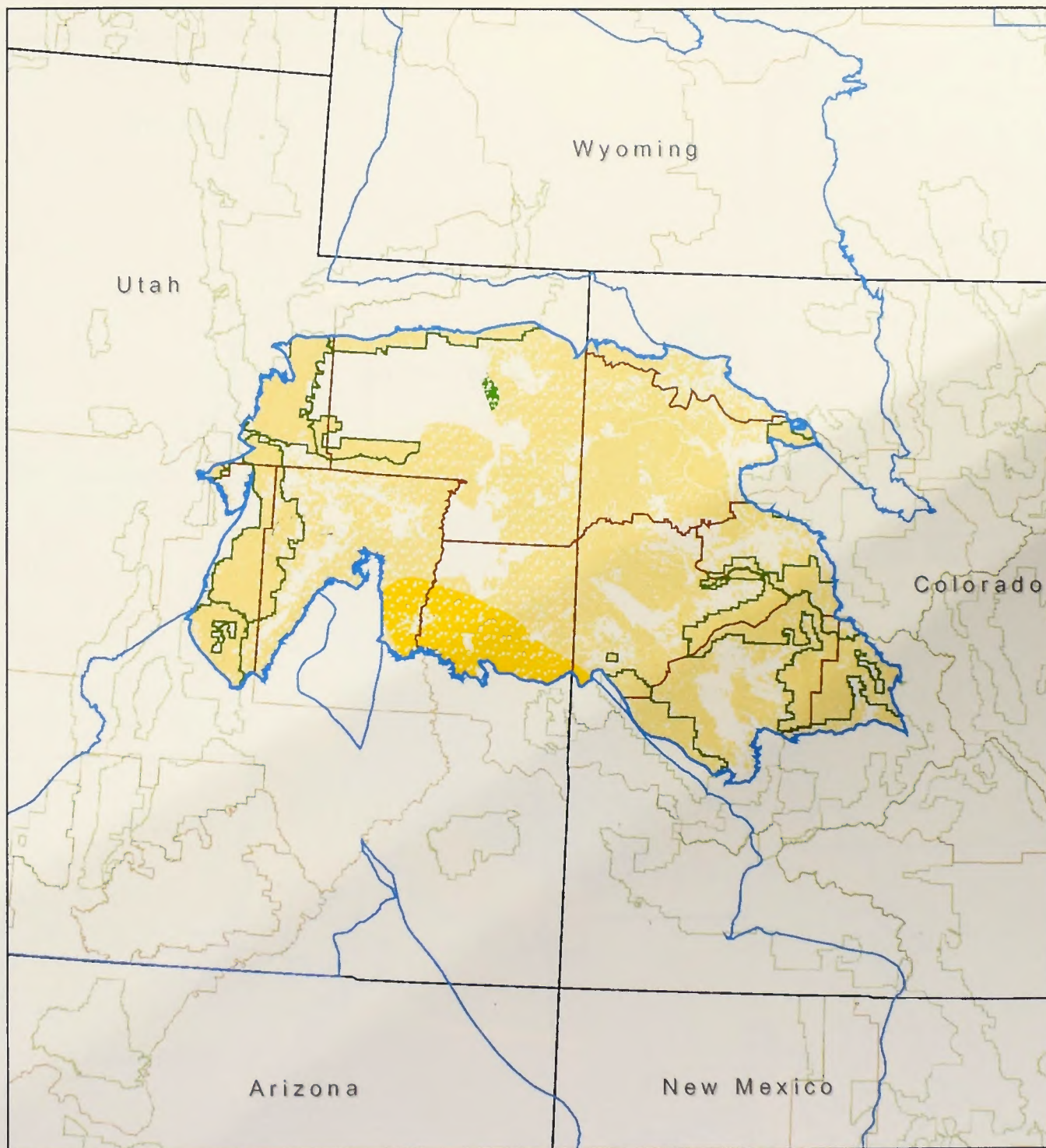
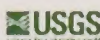
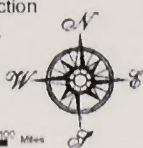


Figure 3k Land Access Categorization – Montana Thrust Belt Study Area





- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



Total Liquids  
Thousands of Barrels Per Square Mile

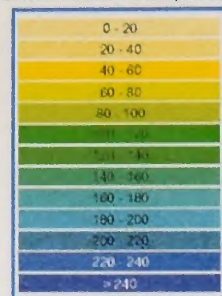


Figure 3m Access Map, Total Liquids – Uinta/Piceance Study Areas - Categories 1-10

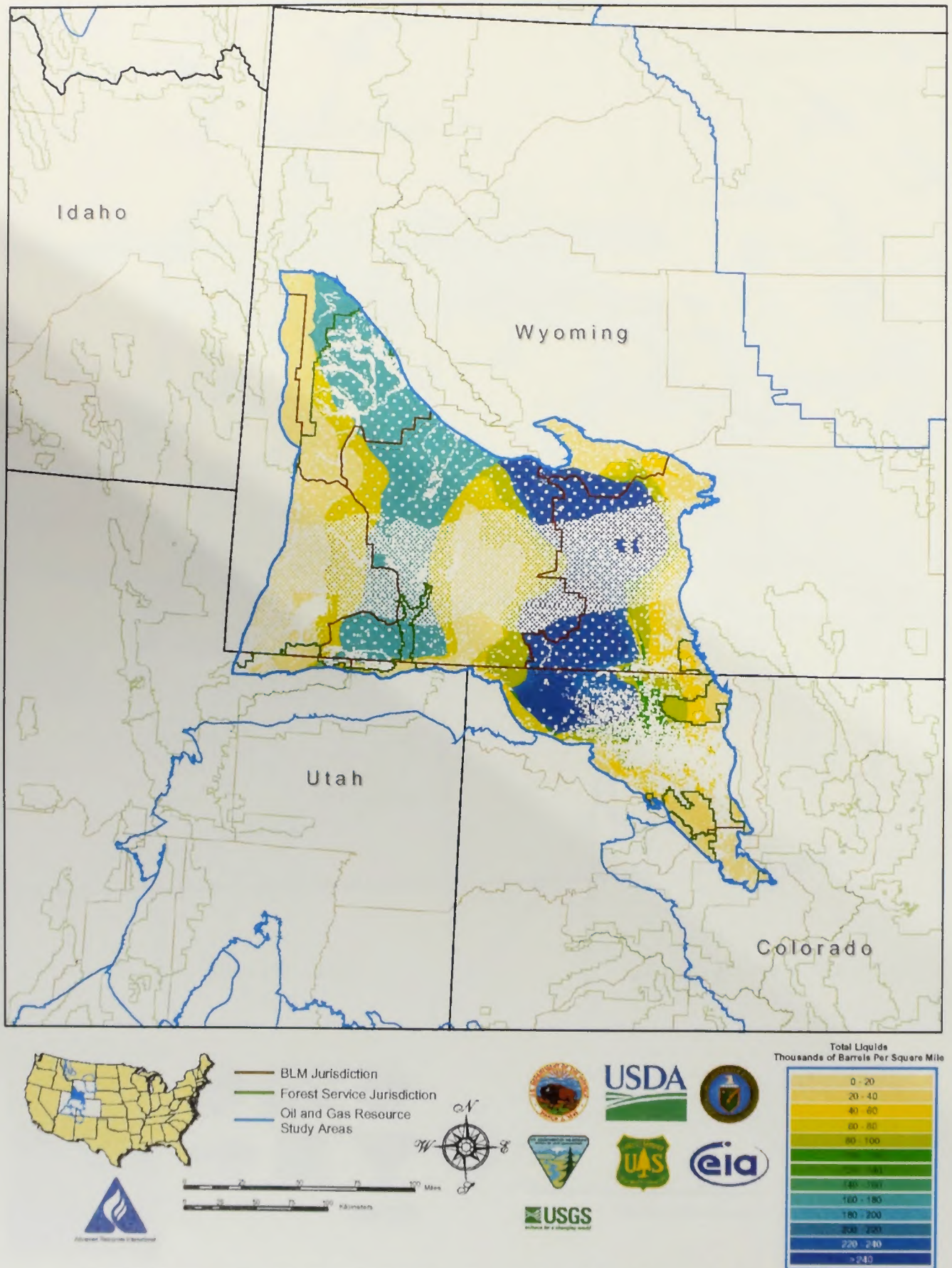


Figure 3n Access Map, Total Liquids – Greater Green River Study Area- Categories 1-10

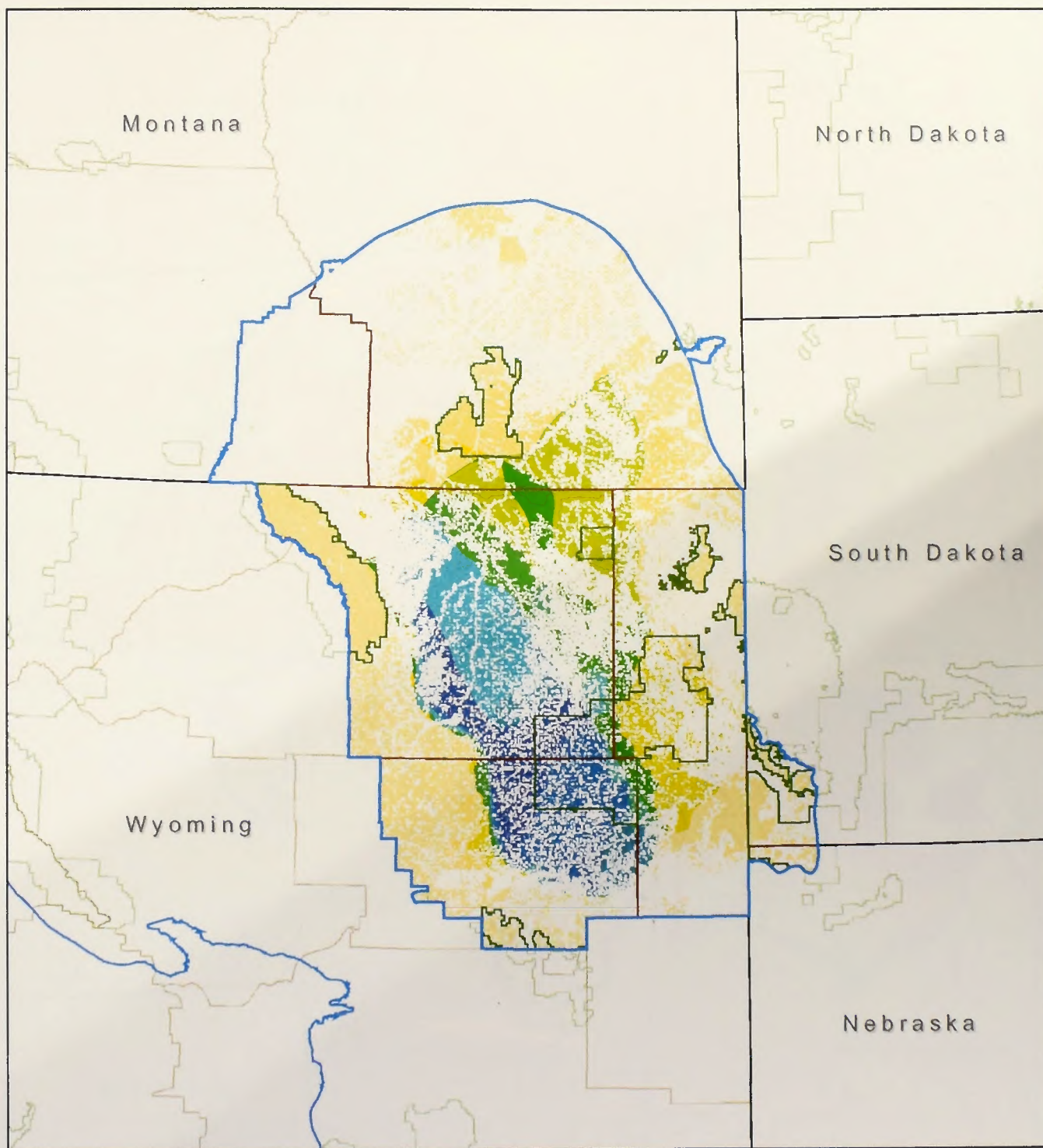


Figure 3o

Access Map, Total Liquids – Powder River Study Area - Categories 1-10

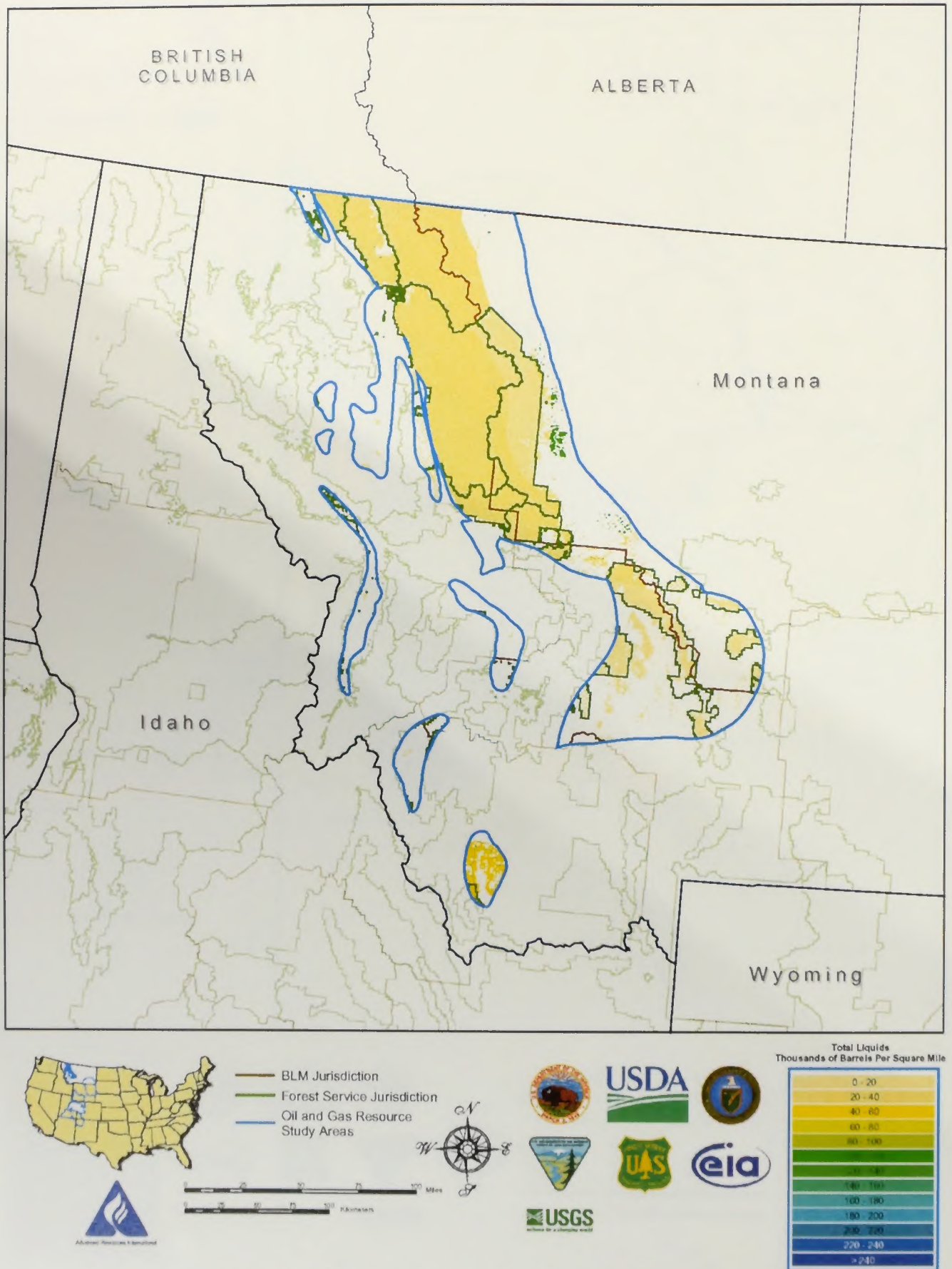
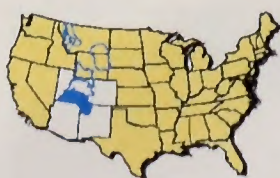
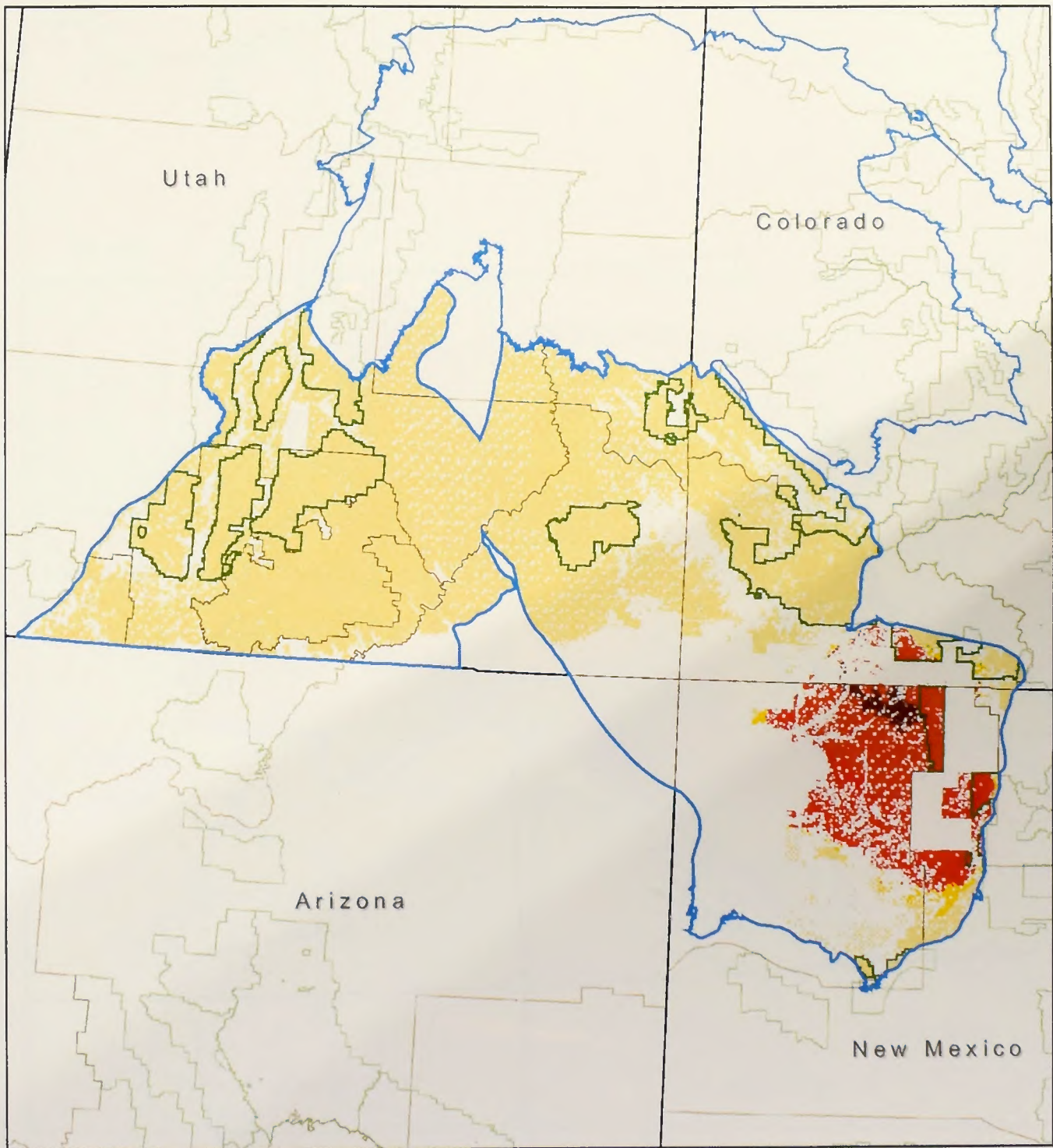
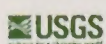
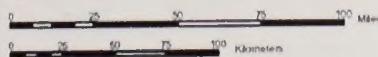
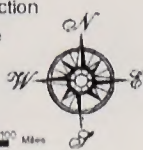


Figure 3p Access Map, Total Liquids – Montana Thrust Belt Study Area - Categories 1-10



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



Total Gas  
Millions of Cubic Feet Per Square Mile

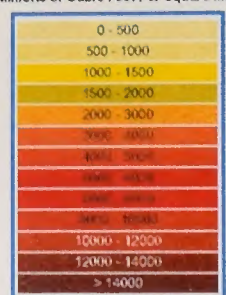


Figure 3q

Access Map, Total Gas – Paradox/San Juan Study Areas - Categories 1-10

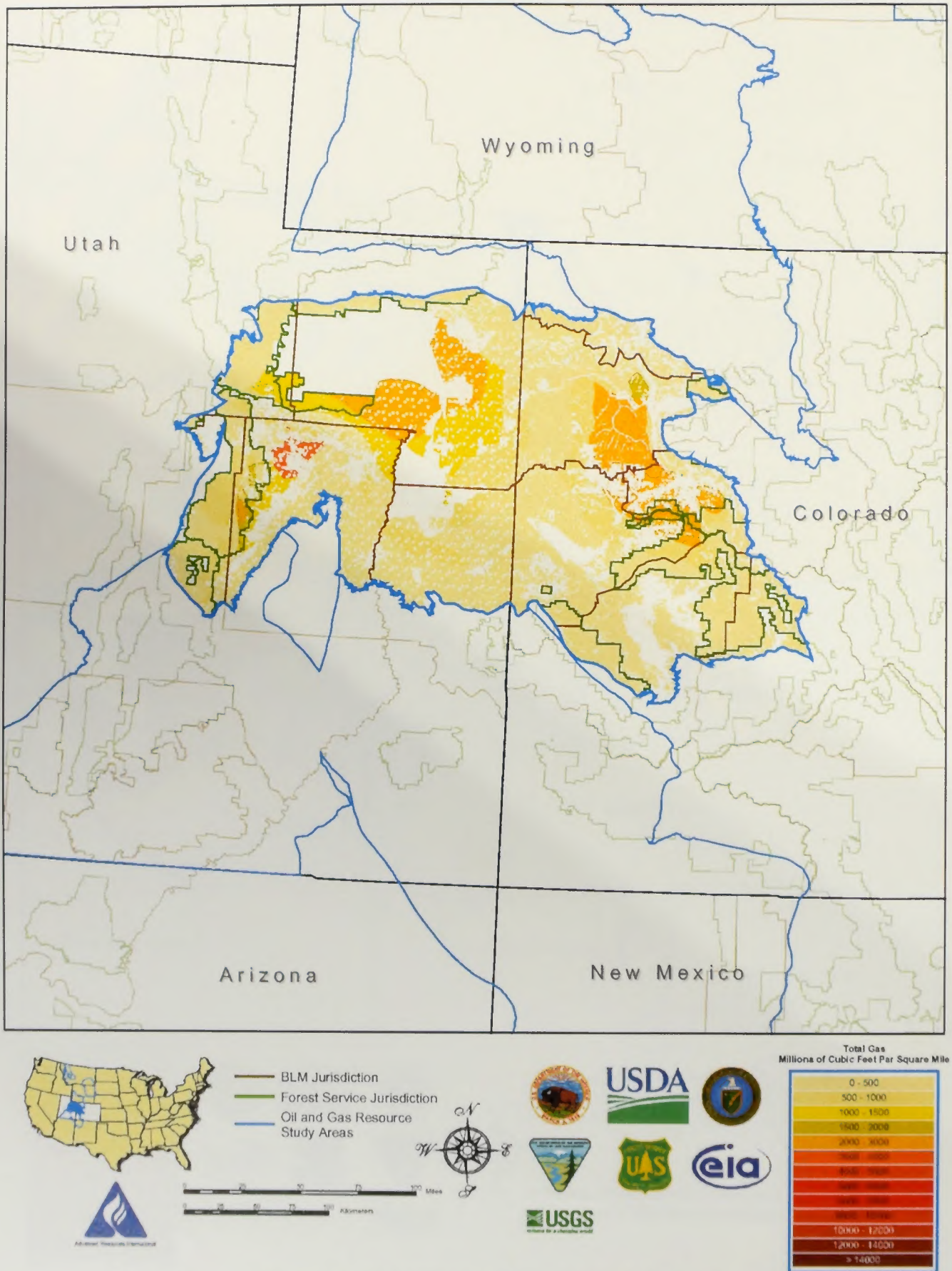


Figure 3r Access Map, Total Gas – Uinta/Piceance Study Areas - Categories 1-10

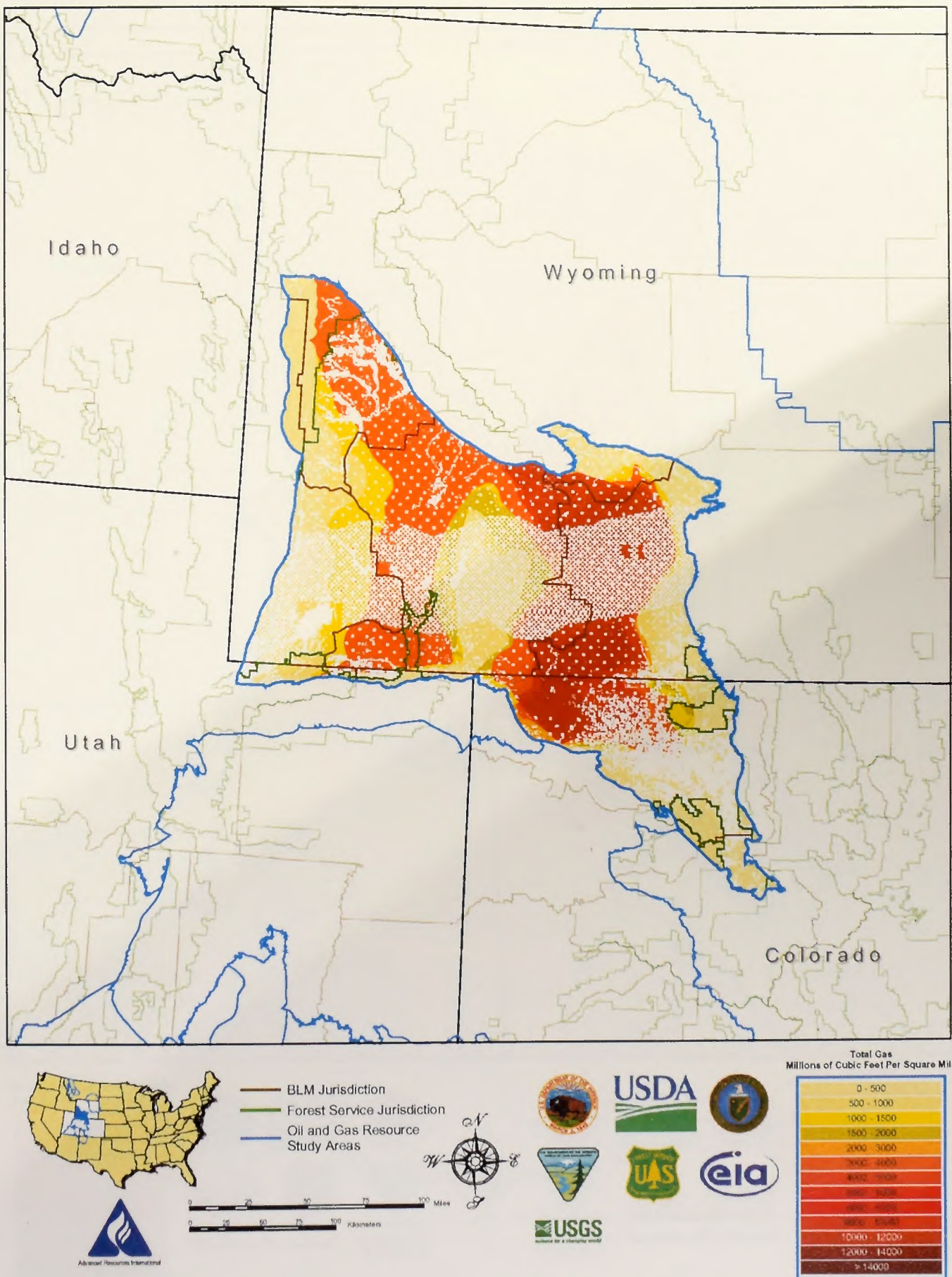


Figure 3s

Access Map, Total Gas – Greater Green River Study Area - Categories 1-10

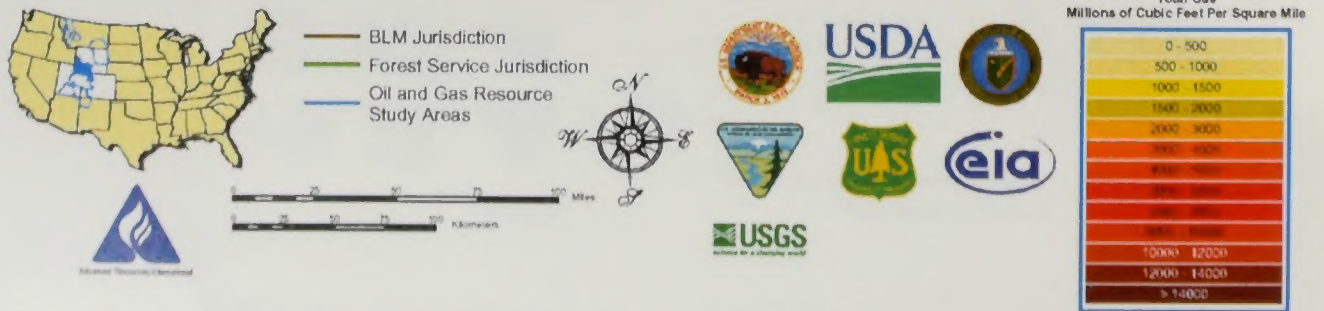
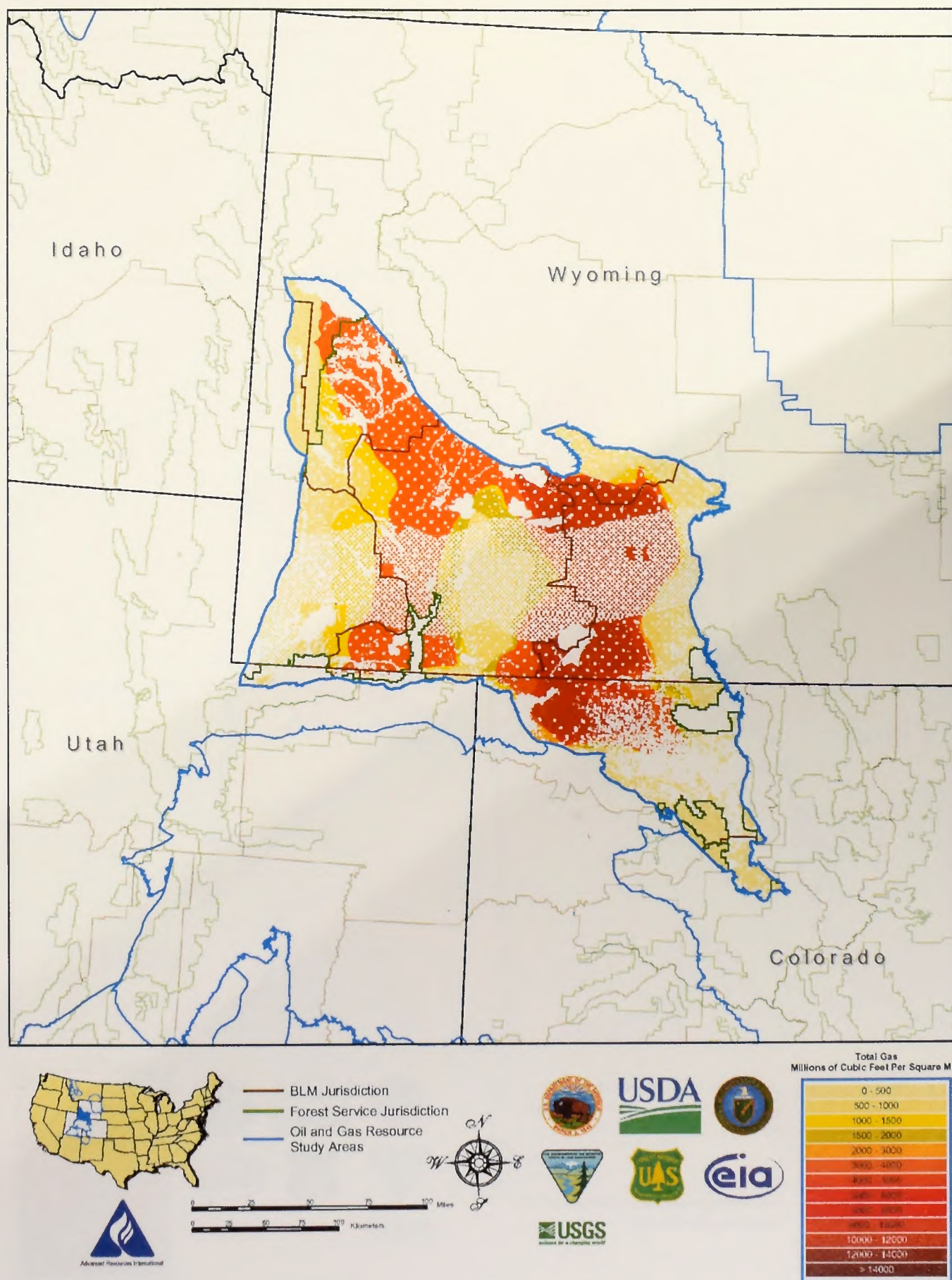


Figure 3t Access Map, Total Gas – Greater Green River Study Area - - Categories 2-10



**Figure 3u**      *Access Map, Total Gas – Greater Green River Study Area - Categories 3-10*

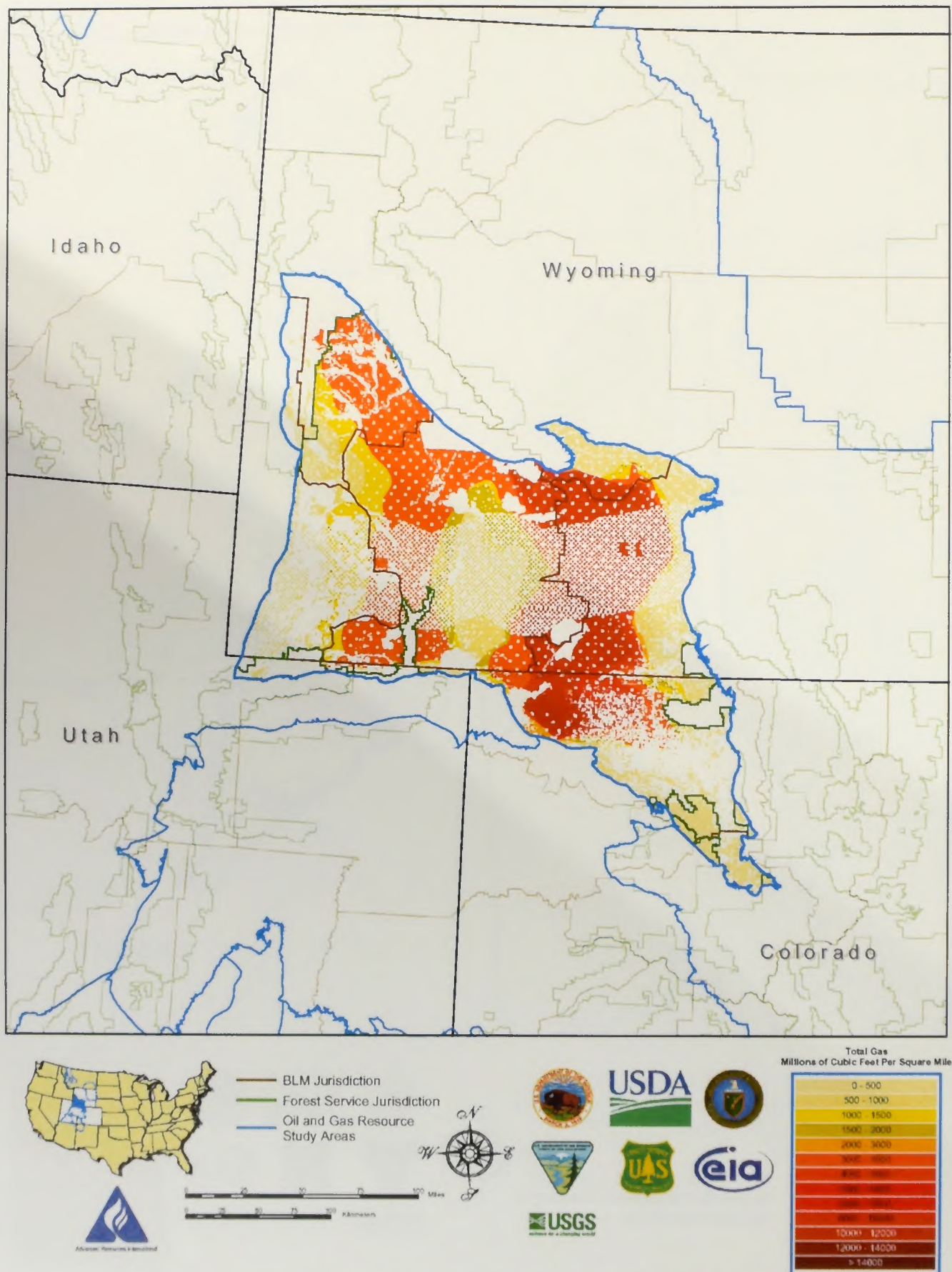
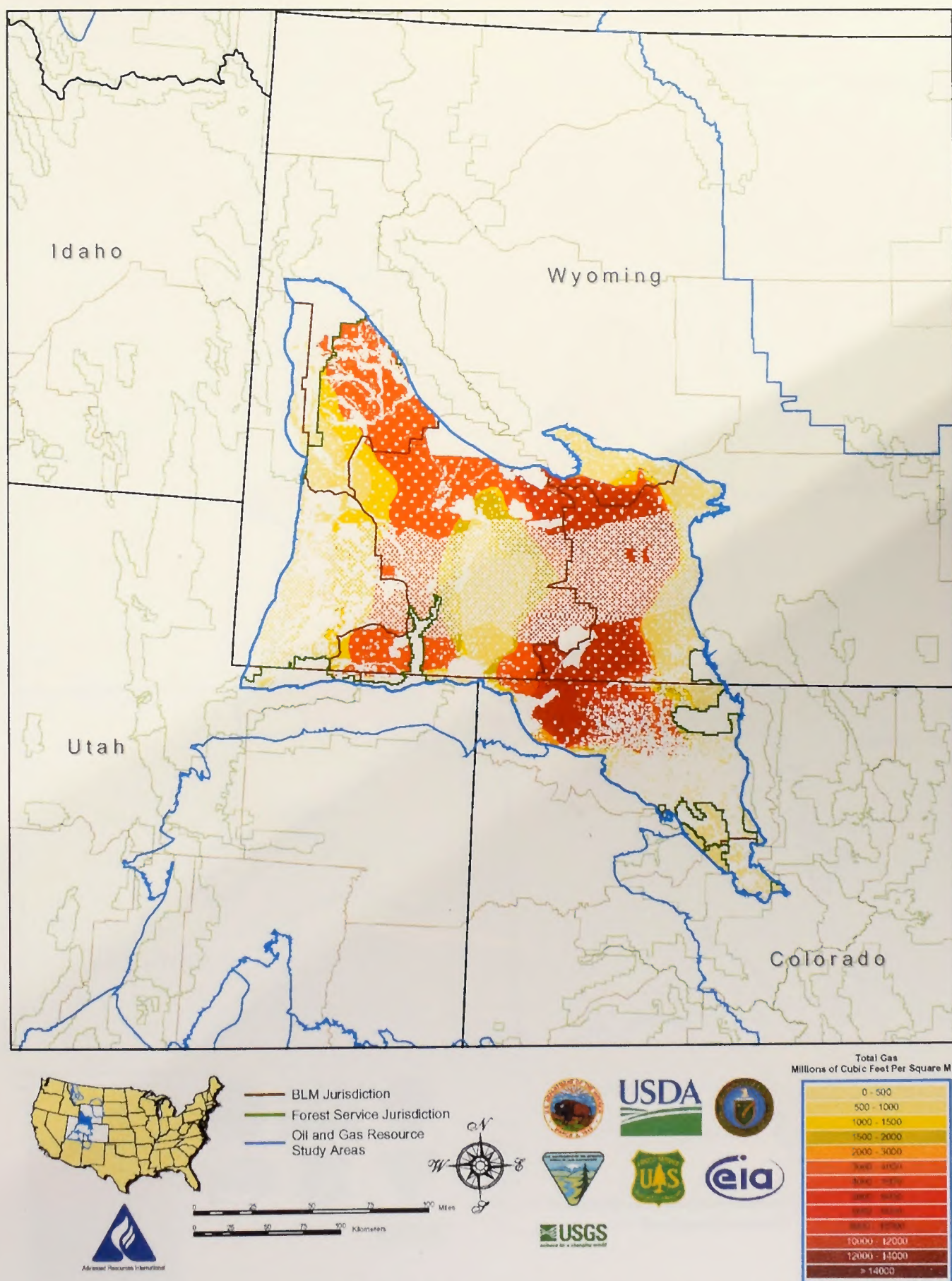


Figure 3v

Access Map, Total Gas – Greater Green River Study Area - Categories 4-10



*Figure 3w*

*Access Map, Total Gas – Greater Green River Study Area - Categories 5-10*

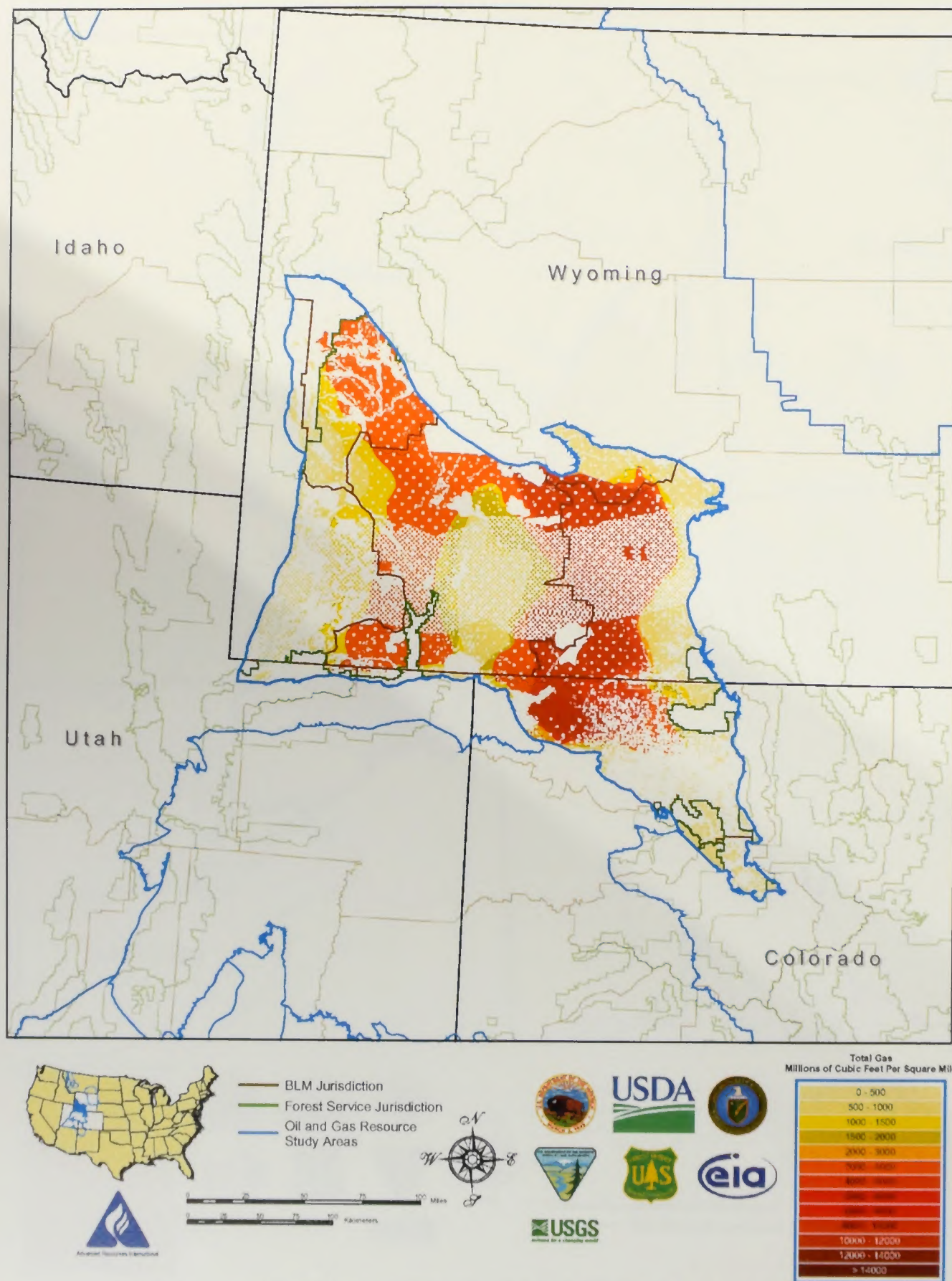


Figure 3x

Access Map, Total Gas, Greater Green River Study Area - Categories 6-10

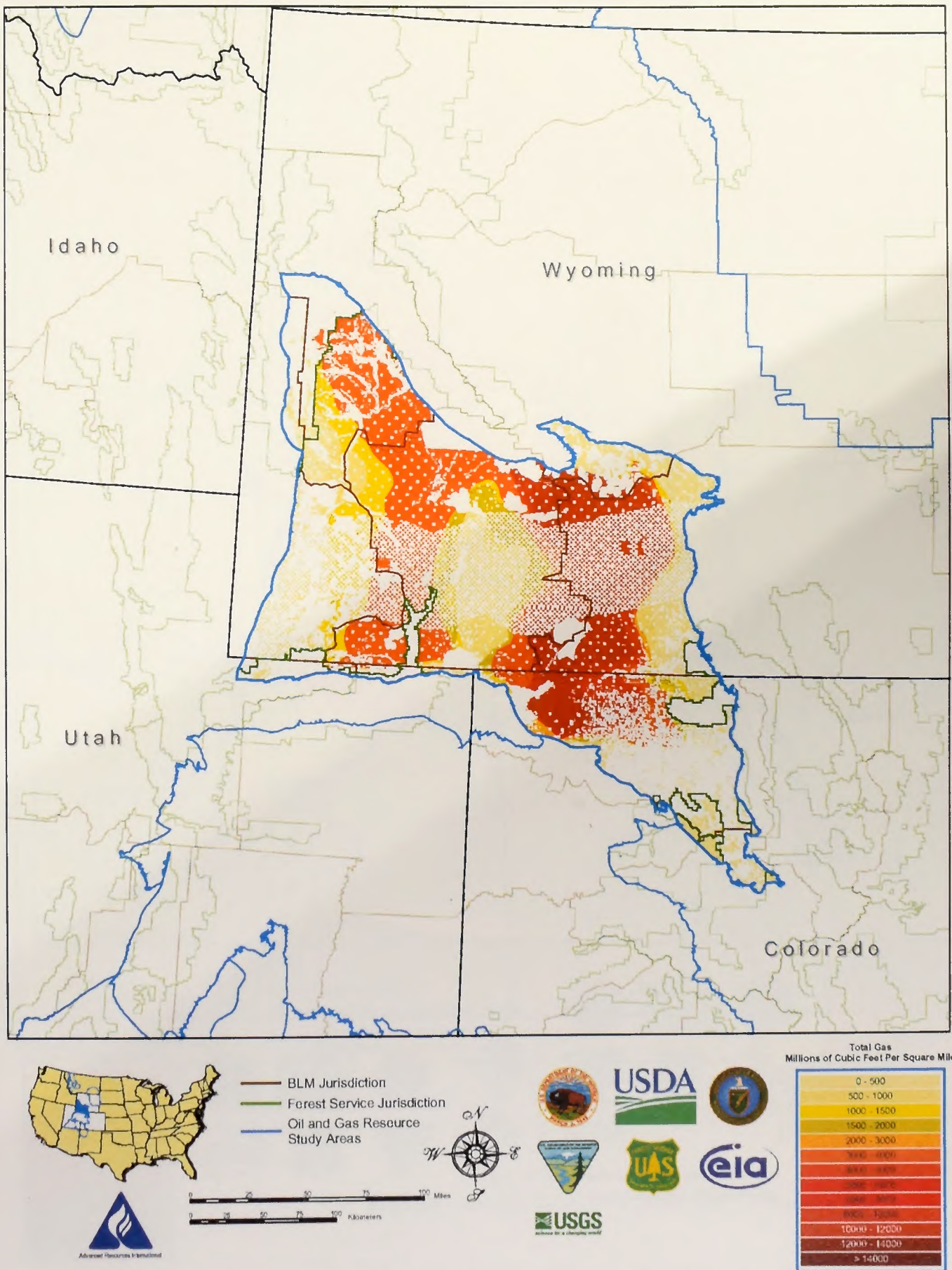


Figure 3y

Access Map, Total Gas – Greater Green River Study Area - Categories 7-10

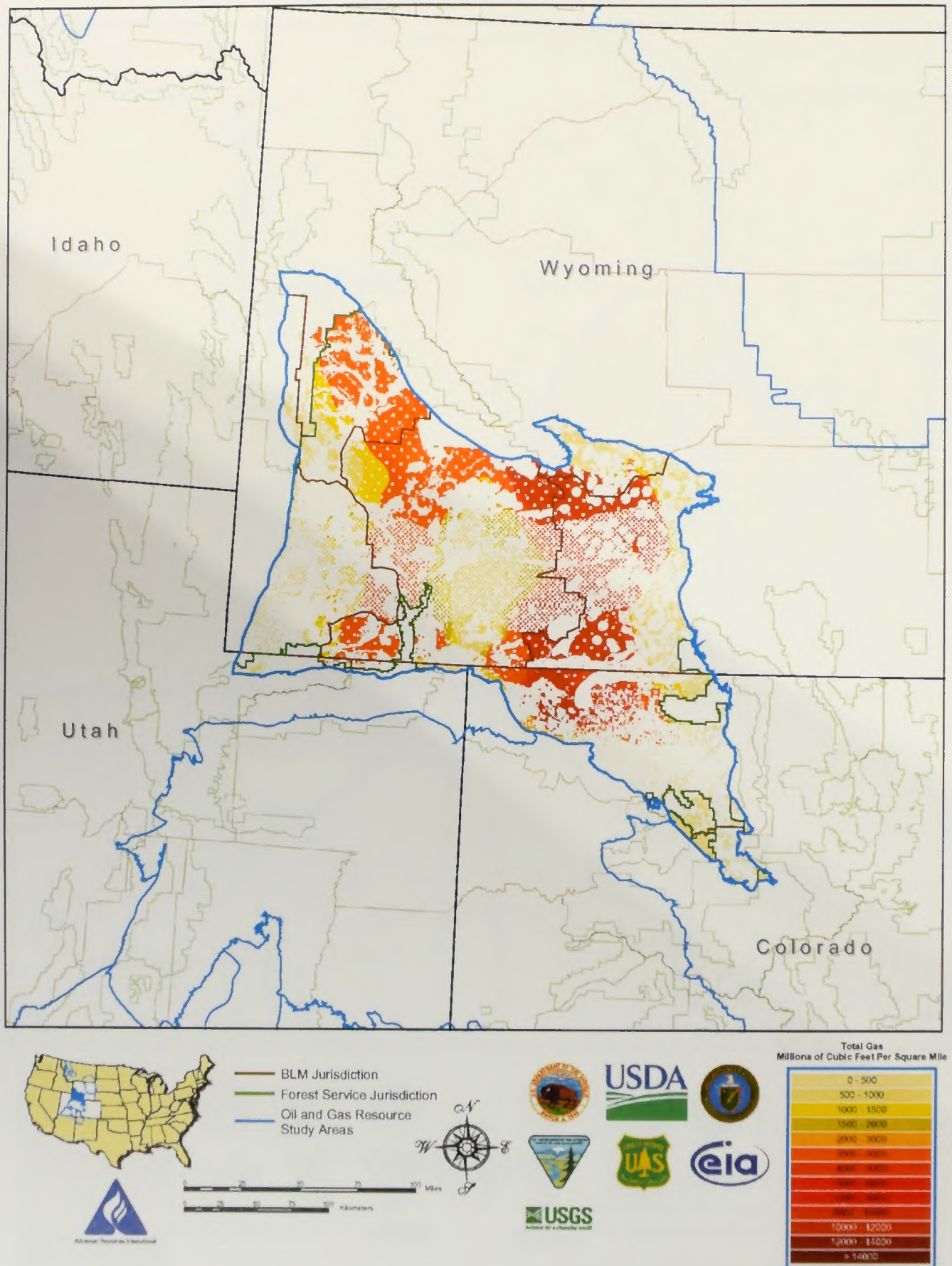
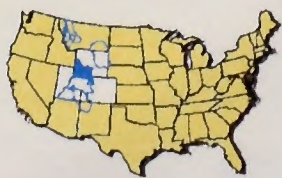
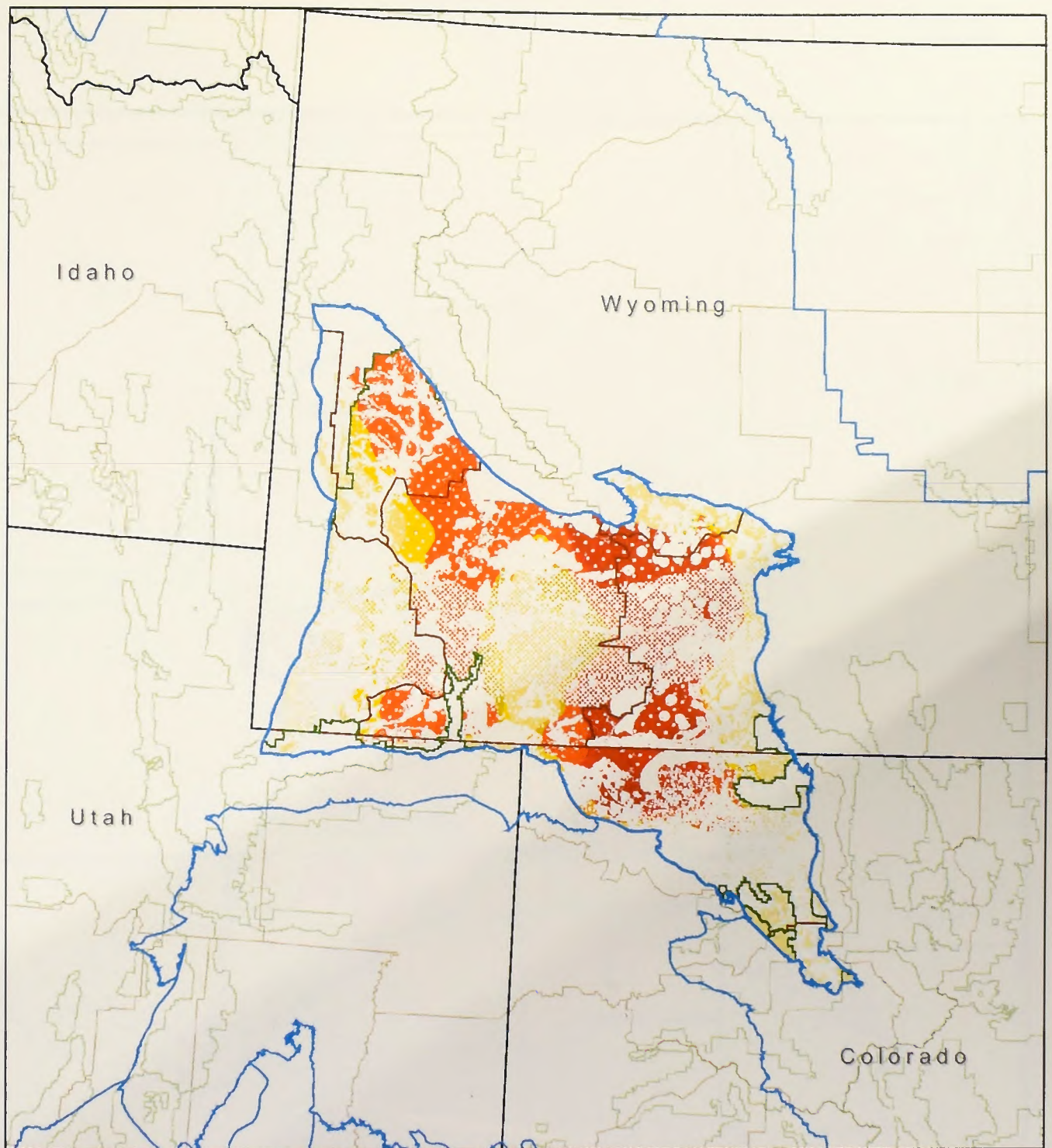
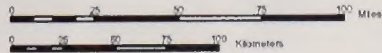


Figure 3z

Access Map, Total Gas – Greater Green River Study Area- Categories 8-10



- BLM Jurisdiction
- Forest Service Jurisdiction
- Oil and Gas Resource Study Areas



Total Gas  
Millions of Cubic Feet Per Square Mile

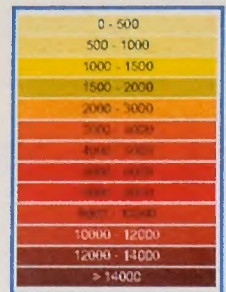


Figure 3aa Access Map, Total Gas – Greater Green River Study Area - Categories 9-10

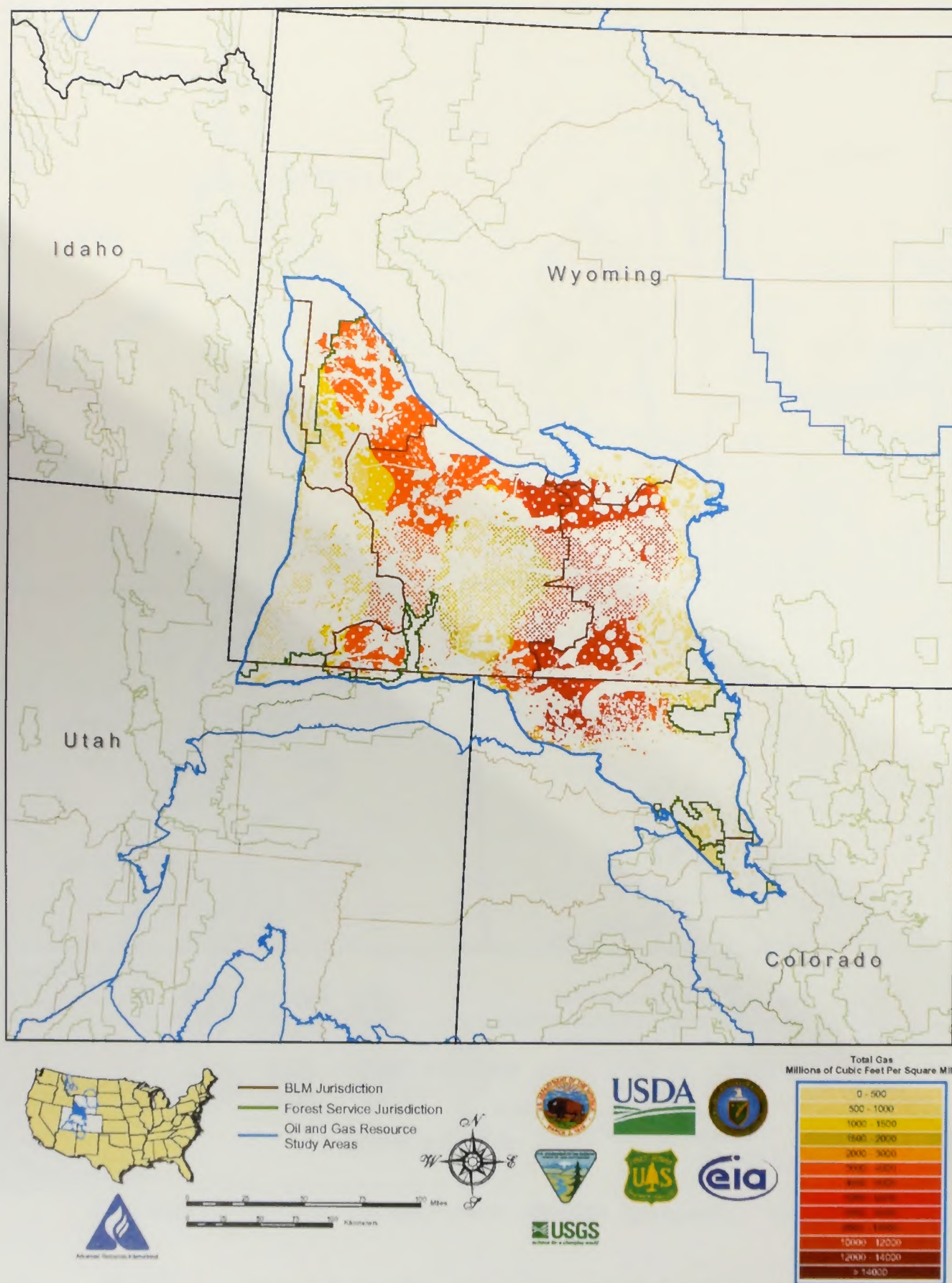
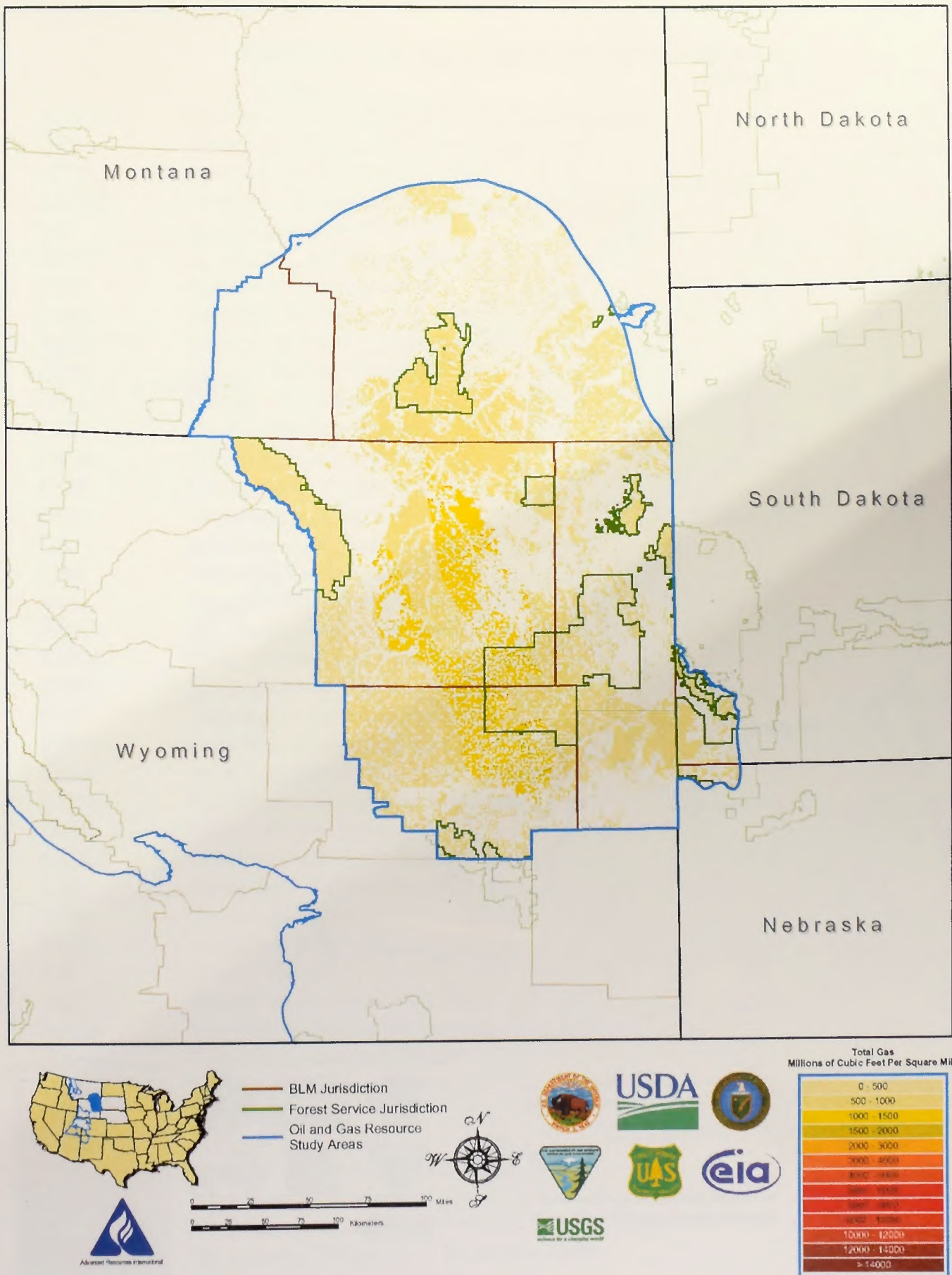


Figure 3ab Access Map, Total Gas -- Greater Green River Study Area - Category 10



**Figure 3ac**      *Access Map, Total Gas -- Powder River Study Area - Categories 1-10*

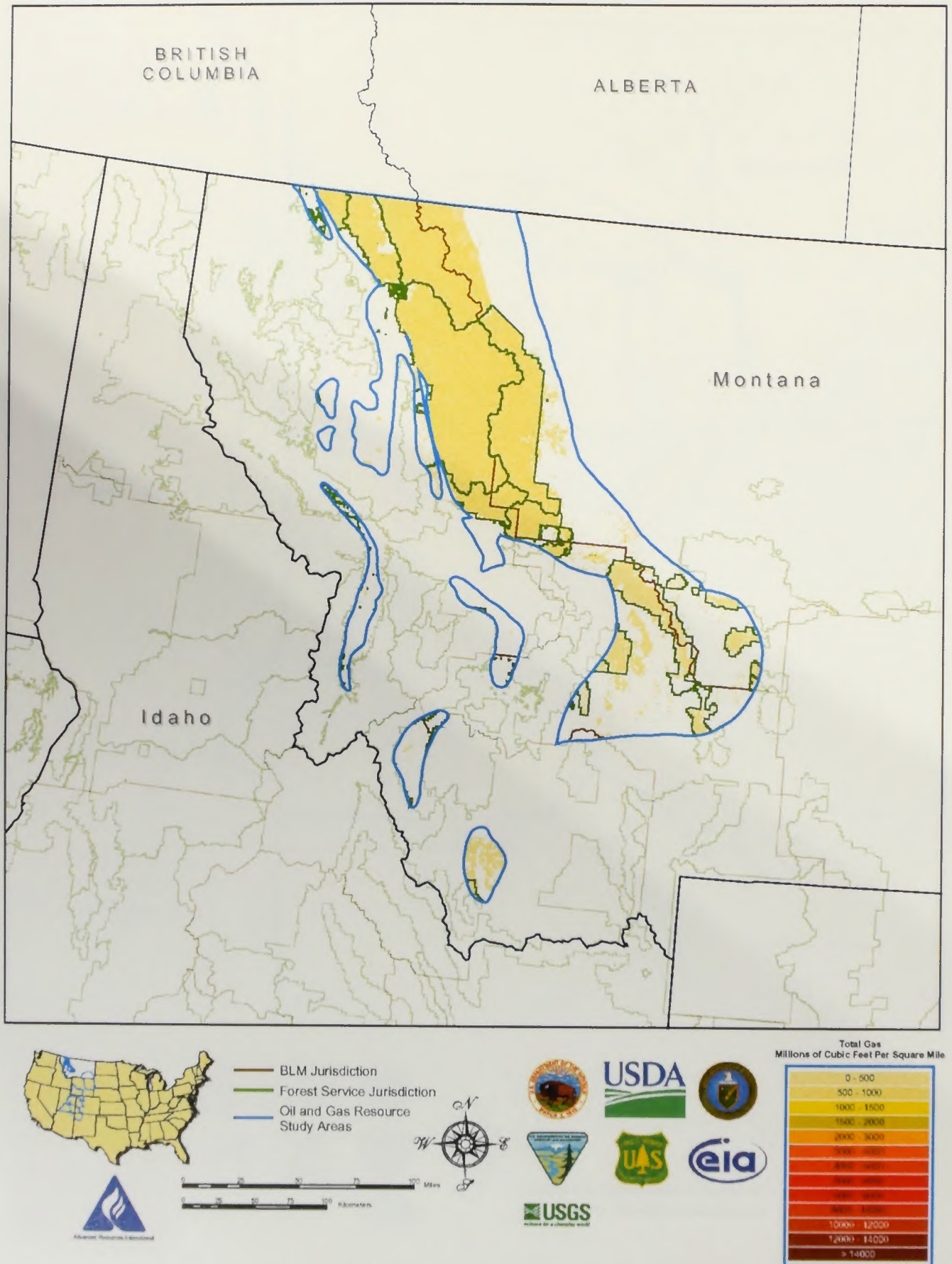


Figure 3ad Access Map, Total Gas – Montana Thrust Belt Study Area - Categories 1-10

## APPENDIX 1

### ACRONYMS AND ABBREVIATIONS

<b>AAPG</b>	American Association of Petroleum Geologists
<b>AD</b>	Associated Dissolved (natural gas)
<b>APD</b>	Application for Permit to Drill
<b>ARMP</b>	Approved Resource Management Plan
<b>bbl</b>	Barrels (of oil)
<b>BLM</b>	Bureau of Land Management
<b>BOE</b>	Barrels of Oil Equivalent
<b>CBM</b>	Coal Bed Methane
<b>CEQ</b>	Council on Environmental Quality
<b>CFR</b>	Code of Federal Regulations
<b>CPAs</b>	Citizen's Proposal Areas
<b>CSU</b>	Control Surface Usage
<b>DEM</b>	Digital Elevation Model
<b>DOE</b>	Department of Energy
<b>DOI</b>	Department of the Interior
<b>EA</b>	Environmental Assessment
<b>EDZ</b>	Extended Drilling Zone
<b>EIA</b>	Energy Information Administration
<b>EIS</b>	Environmental Impact Statement
<b>EPCA</b>	Energy Policy and Conservation Act
<b>ESRI</b>	Environmental Systems Research Institute
<b>EUR</b>	Estimated Ultimate Recovery
<b>FDGC</b>	Federal Geographic Data Committee
<b>FEIS</b>	Final Environmental Impact Statement
<b>GCDB</b>	Geographic Coordinate Database
<b>GGR</b>	Greater Green River
<b>GGRB</b>	Greater Green River Basin
<b>GIS</b>	Geographic Information System
<b>GOR</b>	Gas to Oil Ratio
<b>LGR</b>	Liquids to Gas Ratio
<b>LR</b>	Legacy Rehost
<b>MFP</b>	Management Framework Plan
<b>MMS</b>	Minerals Management Service
<b>NA</b>	Non-Associated natural gas
<b>NEPA</b>	National Environmental Policy Act
<b>NF</b>	National Forest
<b>NGLs</b>	Natural Gas Liquids
<b>NHRP</b>	National Register of Historic Places
<b>NLA</b>	No Leasing, Administrative
<b>NLA/LUP</b>	No Leasing, Administrative/Land Use Planning
<b>NLS</b>	No Leasing, Statutory or Executive Order
<b>NPC</b>	National Petroleum Council

**Appendix 1**  
**Acronyms and Abbreviations**

<b>NSO</b>	No Surface Occupancy
<b>PLSS</b>	Public Land Survey System
<b>RA</b>	Recreation Areas
<b>RMP</b>	Resource Management Plan
<b>ROD</b>	Record of Decision
<b>ROW</b>	Right-of-Way
<b>RPD</b>	Reserves and Production Division of the EIA
<b>SLT</b>	Standard Lease Terms
<b>SUPO</b>	Surface Use Plan of Operations
<b>Tcf</b>	Trillion cubic feet of natural gas
<b>TL</b>	Timing Limitation
<b>TLS</b>	Timing Limitation Stipulation
<b>TPS</b>	Total Petroleum System
<b>URA</b>	Ultimate recovery appreciation
<b>USDA</b>	United States Department of Agriculture
<b>USDA-FS</b>	U.S. Department of Agriculture-Forest Service
<b>USFWS</b>	United States Fish and Wildlife Service
<b>USGS</b>	United States Geologic Survey
<b>WRAs</b>	Wilderness Reinventory Areas

## APPENDIX 2

### GLOSSARY OF TERMS

#### -A-

**Access Probability:** The probability, expressed as a decimal fraction, of sufficient access (political and physical) to a particular assessment unit within a given time frame for the activities necessary to find an accumulation of minimum size and to add its volume to proved reserves. The time frame for this assessment is 30 years.

**Accumulation:** Consists of two types: conventional and continuous. A conventional accumulation is an individual producing unit consisting of a single pool or multiple pools of petroleum grouped on, or related to, a single structural or stratigraphic feature. A continuous accumulation is also an individual producing unit but has a really extensive pool or pools of petroleum not necessarily related to structural or stratigraphic features.

**Affected Environment:** Surface or subsurface resources (including social and economic elements) within or adjacent to a geographic area that could potentially be affected by oil and gas activities; the environment of the area to be affected or created by the alternatives under consideration. (40 Code of Federal Regulations (CFR) 1502.15)

**Alternative:** A combination of management prescriptions applied in specific amounts and locations to achieve a desired management emphasis as expressed in goals and objectives. One of several policies, plans, or projects proposed for decision-making. An alternative need not substitute for another in all respects.

**Alternative, No Action:** An alternative that maintains established trends or management direction.

**Application:** A written request, petition, or offer to lease lands for the purpose of oil and gas exploration and/or the right of extraction.

**Application for Permit to Drill (APD):** An application to drill a well submitted by a lessee or operator to the BLM. The APD consists of a Drilling Plan that discusses downhole specifications and procedures (reviewed by the BLM) and a Surface Use Plan of Operations (SUPO) that examines surface uses, including access roads, well site layout, cut and fill diagrams, reclamation procedures, production facility locations, etc. (reviewed by the surface-managing agency). The approved APD is a contract between the operator and the Federal government and cannot be changed or modified unless authorized by the BLM and the surface-managing agency.

**Aquifer:** (1.) A layer of material that contains water. (2.) The part of a water-drive reservoir that contains the aquifer.

**Archeological/historic site:** A site that contains either objects of antiquity or cultural values relating to history and/or prehistory that warrant special attention.

**Assessment Unit Probability:** Represents the likelihood, expressed as a decimal fraction, that, in a given assessment unit, at least one undiscovered accumulation of a selected minimum size

exists that has the potential for its volume to be added to proved reserves in a given time frame. The assessment unit probability is the product of the probabilities of the three geologic attributes (charge, rocks, and timing) and the probability of access.

**Associated/Dissolved Gas:** Natural gas that occurs in an oil accumulation, either as a free gas cap or in solution; synonymous with gas in oil accumulations.

## **-B-**

**Barrels of Oil Equivalent (BOE):** A unit of petroleum volume in which the gas portion is expressed in terms of its energy equivalent in barrels of oil. For this assessment, 6,000 cubic feet of gas equals 1 BOE.

**Basin:** 1. A depressed area with no surface outlet. 2. A low in the Earth's crust of tectonic origin in which sediments have accumulated.

**Big Game:** Larger species of wildlife that are hunted, such as elk, deer, bighorn sheep, and pronghorn antelope.

**Big Game Winter Range:** An area available to and used by big game (large mammals normally managed for sport hunting) through the winter season.

**Buffer Zone:** 1. An area between two different land uses that is intended to resist, absorb, or otherwise preclude developments or intrusions between the two use areas. 2. A strip of undisturbed vegetation that retards the flow of runoff water, causing deposition of transported sediment

**Bureau of Land Management:** The Department of the Interior agency responsible for managing most Federal onshore subsurface minerals. It also has surface management responsibility for Federal lands designated under the Federal Land Policy and Management Act of 1976.

## **-C-**

**Candidate Species:** 1. A species for which substantial biological information exists on file to support a proposal to list it as endangered or threatened, but for which no proposal has yet been published in the *Federal Register*. The list of candidate species is revised approximately every two years in the Notice of Review. 2. Any species not yet officially listed, but undergoing a status review or proposed for listing according to *Federal Register* notices published by the Secretary of the Interior or the Secretary of Commerce.

**Casing:** Steel pipe placed in an oil or gas well to prevent the hole from caving.

**Cell:** A subdivision or area within an assessment unit having dimensions related to the drainage areas of wells (not to be confused with finite-element cells). Three categories of cells are recognized: cells tested by drilling, untested cells, and untested cells having potential to provide additions to reserves within the forecast span of the assessment. A continuous-type assessment unit is a collection of petroleum-containing cells.

**Completion:** The activities and methods to prepare a well for production. Includes installation of equipment for production from an oil or gas well.

**Composite Total Petroleum System:** A mappable entity encompassing all or a portion of two or more total petroleum systems. Composite total petroleum systems are used when accumulations within an assessment unit are assumed to be charged by more than one source rock.

**Continuous-Type Accumulation:** A petroleum accumulation that is pervasive throughout a large area, that is not significantly affected by hydrodynamic influences, and for which the chosen methodology for assessment of sizes and number of discrete accumulations is not appropriate. Continuous-type accumulations lack well-defined down-dip water contacts. The terms “continuous-type accumulation” and “continuous accumulation” are used interchangeably.

**Controlled Surface Use (CSU):** Allowed use and occupancy (unless restricted by another stipulation) with identified resource values requiring special operational constraints that may modify the lease rights. CSU is used as an operating guideline, not as a substitute for NSO or Timing Lease (TL) stipulations.

**Conventional Accumulation:** A discrete accumulation, commonly bounded by a down-dip water contact that is significantly affected by the buoyancy of petroleum in water. This geologic definition does not involve factors such as water depth, regulatory status, or engineering techniques.

**Council on Environmental Quality (CEQ):** An advisory council to the President established by the National Environmental Policy Act of 1969. It reviews Federal programs for their effect on the environment, conducts environmental studies, and advises the President on environmental matters.

**Crucial Winter Range:** Winter habitat on which a wildlife species depends for survival. Because of severe weather conditions or other limiting factors, no alternative habitat would be available.

**Cultural Resources:** Those fragile and nonrenewable physical remains of human activity, occupation, or endeavor reflected in districts, sites, structures, buildings, objects, artifacts, ruins, works of art, architecture, burial mounds, petroglyphs, and natural features that were of importance in past human events. These resources consist of (1) physical remains; (2) areas where significant human events occurred, even though evidence of the event no longer remains; and (3) the environment immediately surrounding the resource. Cultural resources are commonly discussed in terms of prehistoric and historic values; however, each period represents a part of the full continuum of cultural values from the earliest to the most recent.

**Cumulative Petroleum Production:** Reported cumulative volume of petroleum that has been produced. Cumulative oil, cumulative gas, and cumulative production are sometimes used as abbreviated forms of this term.

## **-D-**

**Directional Drilling:** The intentional deviation of a wellbore from vertical to reach subsurface areas off to one side from the drilling site.

**-E-**

**Endangered Species:** As defined in the Federal Endangered Species Act, any species that is in danger of extinction throughout all or a significant portion of its range. For terrestrial species, the U.S. Fish and Wildlife Service determines *endangered* status.

**Environmental Assessment (EA):** A public document for which a Federal agency is responsible that serves to: (1) briefly provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or a finding of no significant impact; (2) help an agency comply with the NEPA when no EIS is necessary; and (3) facilitate the preparation of an EIS when one is necessary. An EA includes brief discussions of the need for the proposal and of the environmental impacts of the proposed action and other alternatives.

**Environmental Impact Statement (EIS):** A written analysis of the impacts on the natural, social, and economic environment of a proposed project or resource management plan.

**Estimated Ultimate Recovery (EUR):** The total expected recoverable volume of oil, gas, and natural gas liquids production from a well, lease, or field under present economic and engineering conditions; synonymous with total recovery.

**-F-**

**Federal Land:** For the purpose of the EPCA study, land owned by the United States, without reference to how the land was acquired or which Federal agency administers the surface; includes mineral estates underlying private surface.

**Field:** A production unit consisting of a collection of oil and gas pools that, when projected to the surface, form an approximately contiguous area that can be circumscribed.

**Field Growth:** The increases in known petroleum volume that commonly occur as oil and gas fields are developed and produced; synonymous with reserve growth.

**Forecast Span:** A specified future time span in which petroleum accumulations have the potential to provide additions to reserves. A 30-year forecast span is used in the USGS assessments, which affects (1) the minimum undiscovered accumulation size, (2) the number of years in the future that reserve growth is estimated, (3) economic assessments, (4) the accumulations that are chosen to be considered, and (5) the risking structure as represented by access risk.

**Forest Plan:** A plan for a unit of the National Forest system that provides for USDA-FS administered lands in the planning area included.

**Forest Service (USDA-FS):** The agency of the United States Department of Agriculture responsible for managing National Forests and Grasslands under the Multiple Use and Sustained Yield Act of 1960.

**-G-**

**Gas Accumulation:** An accumulation with a gas to oil ratio of 20,000 cubic feet/barrel or greater.

**Gas in Gas Accumulations:** Gas volumes in gas accumulations.

**Gas in Oil Accumulations:** Gas volumes in oil accumulations.

**Gas to Oil Ratio (GOR):** The ratio of gas to oil (in cubic feet/barrel) in an accumulation. GOR is calculated using known gas and oil volumes at surface conditions.

**Geographic Information System (GIS):** In the strictest sense, a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e., data identified according to their locations.

**Geologic Province:** A USGS-defined area having characteristic dimensions of perhaps hundreds to thousands of kilometers encompassing a natural geologic entity (for example, a sedimentary basin, thrust belt, or delta) or some combination of contiguous geologic entities.

**Geospatial:** Information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth. This information may be derived from remote sensing, mapping, and surveying technologies, or from other sources.

**Grown Petroleum Volume:** Known petroleum volume adjusted upward to account for future reserve growth. Thirty years of reserve growth is considered for the USGS assessments.

## **-H-**

**Habitat:** A specific set of physical conditions that surround a single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.

## **-I-**

## **-J-**

## **-K-**

**Known Petroleum Volume:** The sum of cumulative production and remaining reserves as reported in the databases used in support of an assessment. Also called estimated total recoverable volume (sometimes called "ultimate recoverable reserves" or "estimated ultimate recovery").

## **-L-**

**Landscape:** A relatively large area of land with common climate, geology, and soils containing predictably occurring terrain features such as slopes, drainage channels, rock outcrops, etc.

**Lease:** An authorization to possess and use public land for a period of time sufficient to amortize capital investments in the land.

**Lease Stipulations:** See Stipulations.

**Liquids to Gas Ratio (LGR):** Ratio of total petroleum liquids (including oil, condensate, and natural gas liquids) to gas (in barrels/million cubic feet) in a gas accumulation. The LGR is calculated using known petroleum liquids and gas volumes at surface conditions. This ratio is used to assess the liquid co-products associated with undiscovered gas in gas accumulations.

## **-M-**

**Mineral:** Organic and inorganic substances occurring naturally, with characteristics and economic uses that bring them within the purview of mineral laws; a substance that may be obtained under applicable laws from public lands by purchase, lease, or pre-emptive entry.

**Minimum Accumulation Size:** The smallest accumulation size (volume of oil in oil accumulations or volume of gas in gas accumulations) that is considered in the assessment process for conventional accumulations.

**Minimum Petroleum System:** The mappable part of a total petroleum system for which the presence of essential elements has been proved by discoveries of petroleum shows, seeps, and accumulations.

**Minimum Total Recovery Per Cell:** The smallest total recovery per cell (volume of oil or gas) that is considered in the assessment process for continuous-type accumulations.

**Mitigation:** Includes the following:

- (1) Avoiding an impact altogether by not taking a certain action or parts of an action.
- (2) Minimizing impacts by limiting the degree of magnitude of the action and its implementation.
- (3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- (4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- (5) Compensating for the impact by replacing or providing substitute resources or environments.

**Monitoring:** The orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting resource management objectives.

## **-N-**

**National Environmental Policy Act (NEPA):** The law that requires a process to assess and document the environmental and social impacts of federal actions. This act establishes policy, sets goals, and provides different ways to carry out the policy.

**National Forest:** A forest or weathershed reservation that is administered by the United States Department of Agriculture-Forest Service for multiple uses, including grazing, logging, and recreation.

**National Register of Historic Places (NRHP):** A Federal Government list of “. . .districts, sites, buildings, structures, and other objects significant in American history, architecture, archeology, and culture.” The National Register is maintained by the National Park Service, U.S. Department of the Interior, and is published in its entirety in the *Federal Register* each year in February.

**Natural Gas Liquids (NGL):** Petroleum that occurs naturally as a gas in the reservoir, but that is a liquid under surface conditions. Natural gas liquids are typically reported separately from crude oil.

**Natural Gas Liquids to Gas Ratio (for oil accumulations):** Ratio of natural gas liquids to gas (in barrels/million cubic feet) in an oil accumulation, calculated using known natural gas liquids and gas volumes at surface conditions. This ratio is used to assess the natural gas liquids associated with undiscovered gas in oil accumulations.

**Non-Associated Gas:** Natural gas that occurs in a gas accumulation; synonymous with gas in gas accumulations.

**No Surface Occupancy (NSO):** A no surface occupancy area where no surface-disturbing activities *of any nature or for any purpose* are allowed. For example, construction or the permanent or long-term placement of structures or other facilities for any purpose would be prohibited in an NSO area. It is also used as a stipulation or mitigation requirement for controlling or prohibiting selected land uses or activities that would conflict with other activities, uses, or values in a given area. When used in this way, the NSO stipulation or mitigation requirement is applied to prohibit one or more specific types of land and resource development activities or surface uses in an area, while other—perhaps even similar— types of activities or uses (for other purposes) would be allowed. For example, protecting important rock art relics from destruction may require closing the area to the staking of mining claims and surface mining, off-road vehicle travel, construction or long-term placement of structures or pipelines, power lines, general purpose roads, and livestock grazing. Conversely, the construction of fences (to protect rock art from vandalism or from trampling or breakage by livestock), an access road or trail, and other visitor facilities to provide interpretation and opportunity for public enjoyment of the rock art would be allowed. Additionally, if there were potential and interest for leasing and development of leasable minerals in the area, then leases for gas and oil, coal, etc., could be issued with a "no surface occupancy" stipulation or mitigation requirement for the rock art site, which would still allow access to the leasable minerals from adjacent lands and underground. The term "no surface occupancy" has no relationship or relevance to the presence of people in an area.

**Notice:** The communication of a pending Federal action; the notification to parties of Federal actions about to be taken. This is a part of due process.

**-O-**

**Occupancy:** Actual possession and use of land in something more than a slight or sporadic manner. As defined as a multiple use component, it is the management of public lands for

occupancy involving the protection, regulated use, and development of lands as sites for economically and socially useful structures, either publicly or privately owned.

**Oil Accumulation:** An accumulation with a gas to oil ratio of less than 20,000 (in cubic feet/barrel).

**Oil in Gas Accumulations:** Oil volumes in gas accumulations. For this assessment, oil in gas accumulations were calculated along with other liquids rather than separately.

**Oil in Oil Accumulations:** Oil volumes in oil accumulations.

**Operator:** An individual, group, association, or corporation authorized to conduct, for example, livestock grazing or oil and gas drilling on public lands.

## **-P-**

**Petroleum:** A collective term for oil, gas, natural gas liquids, and tar.

**Play:** A set of known or postulated oil and gas accumulations sharing similar geologic, geographic, and temporal properties, such as source rock, migration pathway, timing, trapping mechanism, and hydrocarbon type. A play may or may not differ from an assessment unit; an assessment unit can include one or more plays.

**Proposed Species:** A species of plant or animal formally proposed by the U.S. Fish and Wildlife Service (USFWS) to be listed as threatened or endangered under the Endangered Species Act.

**Proved Reserves:** Quantities of crude oil, natural gas, or natural gas liquids that geological and engineering data demonstrate with reasonable certainty (defined as 90 percent or more probable) to be recoverable in future years from known reservoirs under existing economic and operating conditions.

**Public Lands:** Any land and interest in land owned by the United States that are administered by the Secretary of the Interior through the BLM, without regard to how the United States acquired ownership, except for (1) lands located on the Outer Continental Shelf and (2) lands held for the benefit of Indians, Aleuts, and Eskimos; includes public domain and acquired lands (see definitions). Vacant, unappropriated, and unreserved public lands, or public lands withdrawn by Executive Order 6910 of November 26, 1934, as amended, or by Executive Order 6964 of February 5, 1935, as amended, and not otherwise withdrawn or reserved, or public lands within grazing district established under Section 1 of the Act of June 28, 1934 (48 Stat. 1269), as amended, and not otherwise withdrawn or reserved.

## **-Q-**

## **-R-**

**Remaining Petroleum Reserves:** Volume of petroleum in discovered accumulations that has not yet been produced. Remaining reserves is sometimes used as an abbreviated form of this term.

**Reserve Growth:** The increases in known petroleum volume that commonly occur as oil and gas accumulations are developed and produced; synonymous with field growth.

**Resource Management Plan (RMP):** A plan that provides the basic, general direction and guidance for BLM-administered public lands in the planning area involved.

**Right-of-Way (ROW):** A permit or easement which authorizes the use of public land for certain specified purposes, commonly for pipelines, roads, telephone lines, etc.; also, the lands covered by such an easement or permit. Does not grant an estate or any kind, only the right of use. May also include a site.

**Riparian Areas:** The vegetation along the banks of rivers and streams and around springs, bogs, wet meadows, lakes, and ponds.

**Roadless:** Refers to an absence of roads that have been constructed and maintained by mechanical means to ensure regular and continuous use.

**Roads:** Vehicle routes that have been improved and maintained by mechanical means to ensure relatively regular and continuous use. (A way maintained strictly by the passage of vehicles does not constitute a road.)

## **-S-**

**Sense of Place:** Sense of place offers a holistic interpretation of a geographic place. It synthesizes a complex grouping of meanings, symbols, values, and feelings associated with a particular locality. It can include social, political, economic, aesthetic, occupational, biological, physical, etc. information, which can be drawn on an individual, community, and/or regional basis. Sense of place combines (1) contemporary (present-day) attachment, (2) traditional cultural use and attachment (perhaps by American Indians or other cultural/ethnic groups), and (3) cultural and heritage sites, properties, and districts.

**Shapefile:** GIS file format usable with ESRI (such as ArcView) and other commercial GIS software. It is a nontopological data structure that does not explicitly store topological relationships. However, unlike other simple graphic data structures, one or more rings represent shapefile polygons. A ring is a closed, non-self-intersecting loop. This structure can represent complex structures, such as polygons, that contain "islands." The vertices of a ring maintain a consistent, clockwise order so that the area to the right, as one "walks" along the ring boundary, is inside the polygon, while the area to the left is outside the polygon.

**Split Estate:** Federal mineral estate administered by the BLM, which is under either private lands, State lands, or lands administered by another Federal agency. On split estate lands, the surface owner or managing agency controls the surface uses but the mineral estate is the dominant estate. However, the BLM coordinates with surface owners on mineral leasing and development. In a few cases, the BLM administers the surface, but the minerals are owned by the State or a private entity.

**Stipulations\*:** Conditions, promises, or demands added to a lease when the environmental and planning record demonstrates the necessity for the stipulations. Stipulations, as such, are neither "standard" nor "special"; they are a necessary modification of the terms of the lease. In order to accommodate the variety of resources encountered on Federal lands, stipulations are categorized as to how the stipulation modifies the lease rights, not by the resource(s) to be protected. What, why, and how this mitigation/protection is to be accomplished is determined by the land management agency through land use planning and NEPA analysis.

If, upon weighing the relative resource values, uses, and/or users, conflict with oil and gas operations is identified that cannot be adequately managed and/or accommodated on other lands, then a lease stipulation is necessary. Land use plans serve as the primary vehicle for determining the necessity for lease stipulations. Documentation of the necessity for a stipulation is disclosed in planning documents or through site-specific analysis. Land use plans and/or NEPA documents also establish the guidelines under which future waivers, exceptions, or modifications may be granted.

Substantial modification or waiver of stipulations subsequent to lease issuance is subject to public review for at least a 30-day period in accordance with Section 5102.f of the Federal Onshore Oil and Gas Leasing Reform Act of 1987 (FOLRA). Stipulations may be necessary if the authority to control the activity on the lease does not already exist under laws, regulations, or orders. An authorized Federal officer has the authority to modify the site location and design of facilities, control the rate of development and timing of activities, and require other mitigation under standard lease term. The necessity for individual lease stipulations is documented in the lease-file record with reference to the appropriate land use plan or other leasing analysis document. The necessity for exceptions, waivers, or modifications is documented in the lease-file record through reference to the appropriate plan or other analysis.

**Study Areas:** The Paradox/San Juan, Uinta/Piceance, Greater Green River, and Powder River Basins, and the Montana Thrust Belt, which were selected as the resource provinces of the study and comprise the areas of these resource provinces underlain by oil and/or natural gas resources based upon USGS analysis.

**Subsurface Allocation:** An allocation of potential additions to reserves to land entities based on subsurface ownership of mineral rights.

**Surface Allocation:** An allocation of potential additions to reserves to land entities based on surface ownership.

**Sweet Spot:** An area within a continuous-type deposit where production characteristics are relatively more favorable.

**-T-**

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\* Taken from the booklet, "Uniform Format for Oil and Gas Lease Stipulations," prepared by the Rocky Mountain Regional Coordinating Committee in March 1989. These guidelines were developed by the BLM and USDA-FS.

**Technically Recoverable Resources:** In-place resources that are producible using current recovery technology but without reference to economic profitability. These are oil and natural gas resources that may be produced at the surface from a well as a consequence of natural pressure within the subsurface reservoir, artificial lifting of oil from the reservoir to the surface, and the maintenance of reservoir pressure by fluid injection. These resources are generally conceived as existing in accumulations of sufficient size to be amenable to the application of existing recovery technology.

**Timing Limitation:** Prohibits surface use during specified time periods to protect identified resource values. The stipulation does not apply to the operation and maintenance of production facilities unless the findings of analysis identify the continued need for such mitigation and demonstrate that less stringent, project-specific mitigation measures would be insufficient. Also called a Seasonal Restriction.

**Total Petroleum System (TPS):** A mappable entity encompassing genetically related petroleum that occurs in seeps, shows, and accumulations (discovered or undiscovered) that have been generated by a pod or by closely related pods of mature source rock, together with the essential mappable geologic elements (source, reservoir, seal, and overburden rocks) that controlled fundamental processes of generation, migration, entrapment, and preservation of petroleum.

**Total Recovery:** The total expected recoverable volume of oil, gas, and natural gas liquids production from a well, lease, or field under present economic and engineering conditions; synonymous with estimated ultimate recovery.

## **-U-**

**Ultimate Recovery Appreciation (URA):** The generally observed increase of Estimated Ultimate Recovery (EUR) over time.

**Undiscovered Petroleum Resources:** Resources postulated from geologic information and theory to exist outside of known oil and gas accumulations.

**USGS-Assessed Petroleum Volumes:** The quantities of oil, gas, and natural gas liquids that have the potential to be added to reserves within some future time frame, which for this assessment is 30 years. The USGS assessed petroleum volumes include both those from undiscovered accumulations, whose sizes are greater than or equal to the selected minimum accumulation size, and those from the reserve growth of fields already discovered.

## **-V-**

## **-W-**

**Wetlands:** Permanently wet or intermittently flooded areas where the water table (fresh, saline, or brackish) is at, near, or above the soil surface for extended intervals; where hydric wet soil conditions are normally exhibited; and where water depths generally do not exceed two meters. Marshes, shallows, swamps, muskegs, lake bogs, and wet meadows are examples of wetlands.

**Wilderness:** A Congressionally designated area of undeveloped Federal land retaining its primeval character and influence, without permanent improvement or human habitation, that is

protected and managed so as to preserve its natural conditions and that (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5,000 acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and, (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

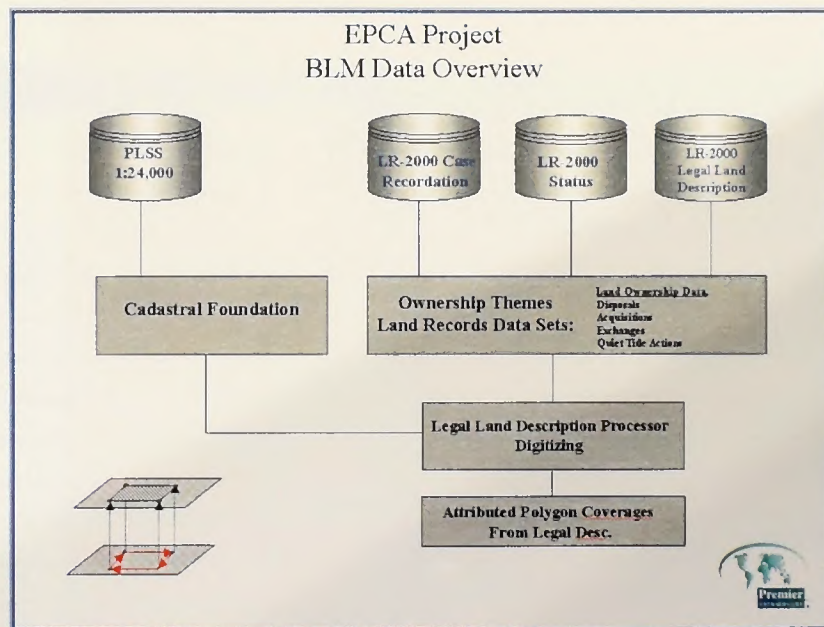
**Wildlife:** All living vertebrate and invertebrate fauna that exist or potentially exist in an area.

**Withdrawal:** An action that restricts the disposition of public lands and that holds them for specific public purposes; also, public lands that have been dedicated to public purposes (for example, recreation sites, office or warehouse sites, etc.).

## APPENDIX 3

### LAND STATUS METHODOLOGY

For purposes of the EPCA project, spatial data themes were created that define various ownership characteristics and categories for lands within the play boundaries. The final data sets were rendered to delineate both surface and subsurface U.S. rights. To accomplish this, ownership cases, extracted from the BLM's LR-2000 Case Recordation and Status Databases, were processed and used to create polygon themes for the project (Figure A3-1).



*Figure A3-1 Schematic of BLM's Primary Land Records Databases*

The primary information that defines U.S. interests in parcels of land are data elements associated with various case categories and land transactions recorded and maintained in the BLM's LR-2000 Case Recordation and Status Databases. The mapped case land records extracted fall within four general categories:

Land Disposals, including patents, grants, deeds, land sales, and all other transactions that conveyed Federal ownership rights in lands from the Federal Government.

Acquired Lands, including lands that were re-acquired by the United States under various legal authorities.

Land Exchanges, including lands exchanged between the Federal Government and other parties.

Quiet Title Cases, including all records established to cure title and quiet adverse claims.

These four major categories formed the basis to extract records from the BLM's databases. The four queries were processed against both the Status and Case Recordation Systems. Due to formatting differences between the two databases, the resulting polygon attributes contained in

the GIS shape files varied slightly. Additionally, in some case records extracted from the Case Recordation system, U.S. rights were not readily available but were determined as accurately as possible through interpretation from land records obtained at BLM State and field offices.

The polygon boundaries created through processing reflect the geometry as described by aliquot part description. Lands described by lot or tract surveys were processed against the BLM Legal Land Description (LLD) file to convert the lot references to nominal aliquot descriptions for mapping purposes. Depending on the actual survey type and geometry, the resulting polygon may contain a degree of generalization. Additionally, the BLM record systems do not contain individual records for public domain lands. The location of these lands was determined through various polygon-processing steps described below. The data elements for the attribute fields contained in the shape files produced from each of the LR-2000 databases are shown in Table A3-1.

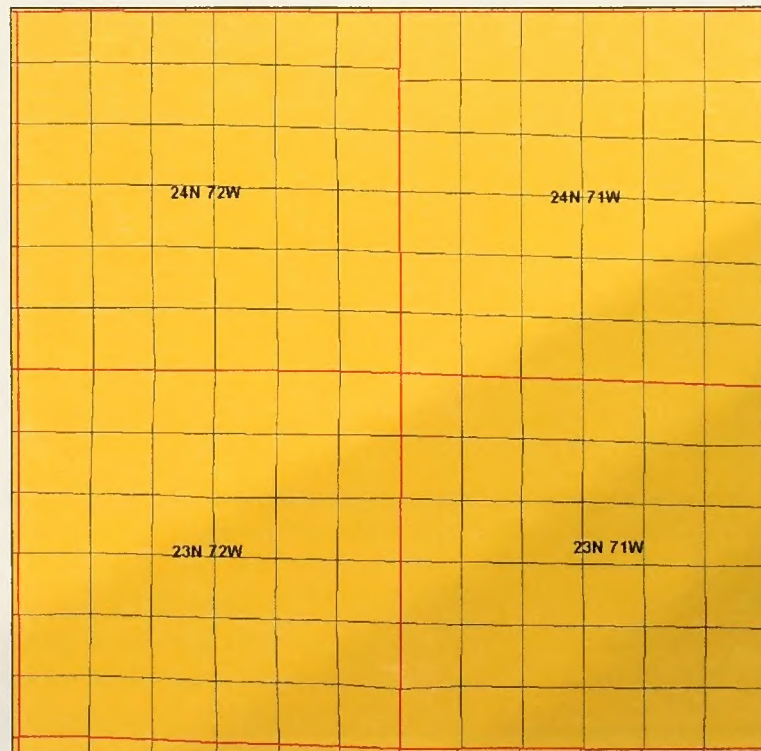
Status Data Attributes*	Case Recordation Attributes*
Shape	Meridian
Meridian	Township
Township	Range
Range	Section
Section	Surveytype
Survey Type	Aliquot
Aliquot	Serialnumb
Adminagenc	Surveynumb
County	Name
State	Percentint
Serialnumb	Price
Docid	Acres
Patent_num	Dispositio
Case_type	Casetype
Usright1	Commodity
Usright2	Expiredate
Usright3	Expireyear
Usright4	Effectdate
Patentissu (mm/dd/yy)	Royaltyrt
Patentiss1 (year)	Geoname
Acres	Hbp
Patentee	Or
Id	Id
*Note: Data fields were populated if data is entered in the Status or Case Recordation database. If U.S. rights are recorded in the US Rights field, they were included in the Commodity field.	

*Table A3-1 Data Elements, LR-2000 Database*

The data simplification process was completed through numerous steps that combined data associated with each of the four broad record categories referenced above using the following processing steps, shown for an example from the Powder River Basin:

1. A Public Land Survey System (PLSS) grid digitized from USGS 7.5-minute quadrangle maps was used as the cadastral reference framework and contains shapefile coverages that define both townships and sections. For example, lands that fall within the geographic extent of the Powder River Basin were acquired in 1803 under the Louisiana Purchase. All surface and subsurface rights belonged to the United States of America.

After the PLSS base was loaded, a master polygon (Figure A3-2) was created to represent the disposition of the lands at the time of the original purchases and annexations by which the United States acquired land.



*Figure A3-2 Master Polygon*

2. The next step involved processing textual legal land descriptions against the section shape file by subdividing according to the survey rules embedded in the CarteView product<sup>1</sup>. Table A3-2 shows a typical input file.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Status	Generic	USRght1	SerialNumber								
2	Meridian	Township	Range	Section	SurveyTy	Aliquot	County	State	SerialNumber	DocID	Case Type	USRght1
1348		6 0160N	0920W	28 T		NW1/4,NW1/4,SW1/4,	7 WY	WYC	0001269	165770	HE ORIGINAL	Coal
1349		6 0160N	0920W	29 T		NENE,NESE,NWNE,NWSE,SENE,SW	7 WY	WYC	0001269	165770	HE ORIGINAL	Coal
1350		6 0160N	0920W	20 T		NESE,NWSE,SESE,SWSE,	7 WY	WYC	0001270	163248	HE ORIGINAL	Coal
1351		6 0160N	0920W	21 T		NWSW,SWSW,	7 WY	WYC	0001270	163248	HE ORIGINAL	Coal
1352		6 0160N	0920W	28 T		NW1/4,	7 WY	WYC	0001270	163248	HE ORIGINAL	Coal
1353		6 0160N	0920W	29 T		NENE,NWNE,	7 WY	WYC	0001270	163248	HE ORIGINAL	Coal

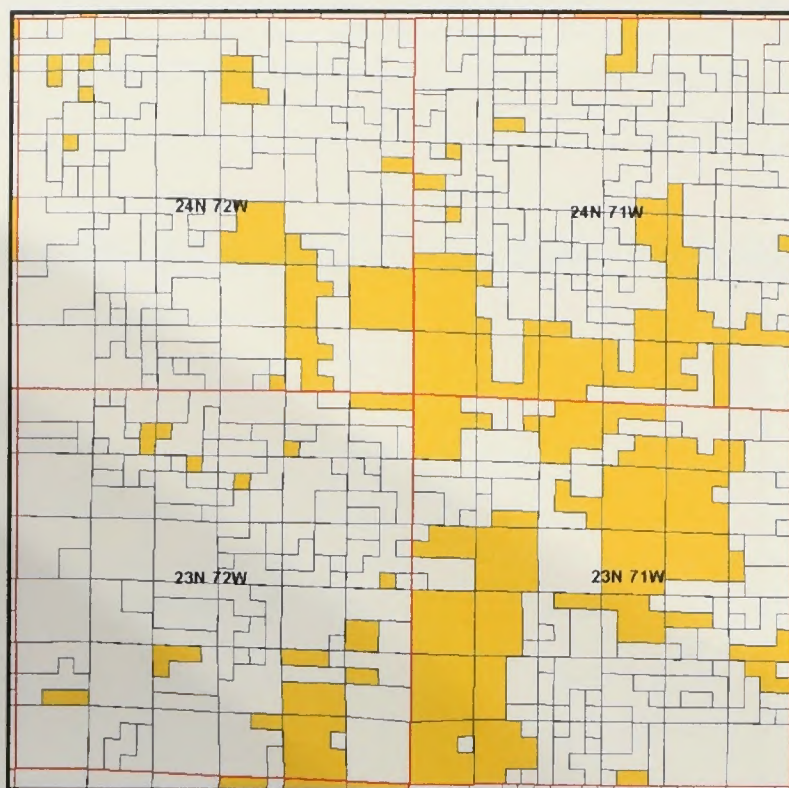
*Table A3-2 Typical CarteView Input File*

3. After the records from the Status and Case Recordation databases were processed, the resulting polygon themes were re-attributed to allow for a merge between the two data sets. The polygons were then overlaid on the Master Polygon to establish the location of lands where ownership left

<sup>1</sup> A product available through Premier Data Services, Inc.

the Federal government by virtue of patent, grant, or other title transfer authority. The resulting coverages are represented in Figure A3-3.

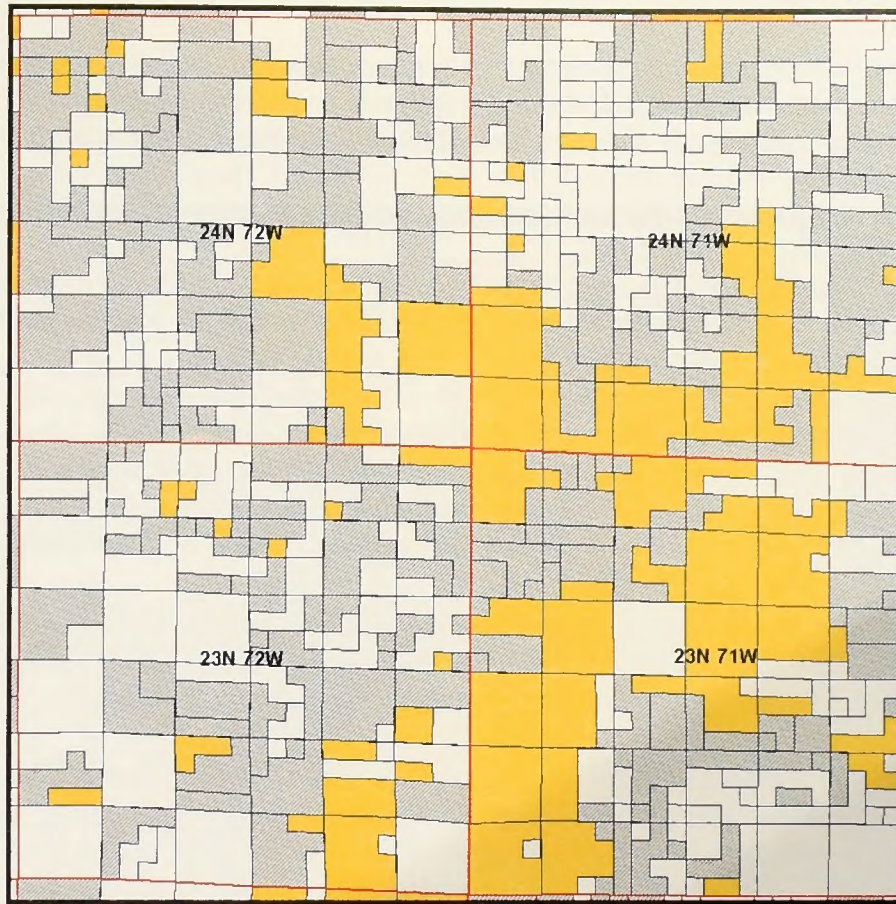
The yellow polygons shown on Figure A3-3 represent lands that remain in the public domain with all surface and subsurface rights managed by the BLM. These public domain lands were then converted to a polygon and attributed to show the current disposition of the U.S rights.



*Figure A3-3      Public Domain Lands*

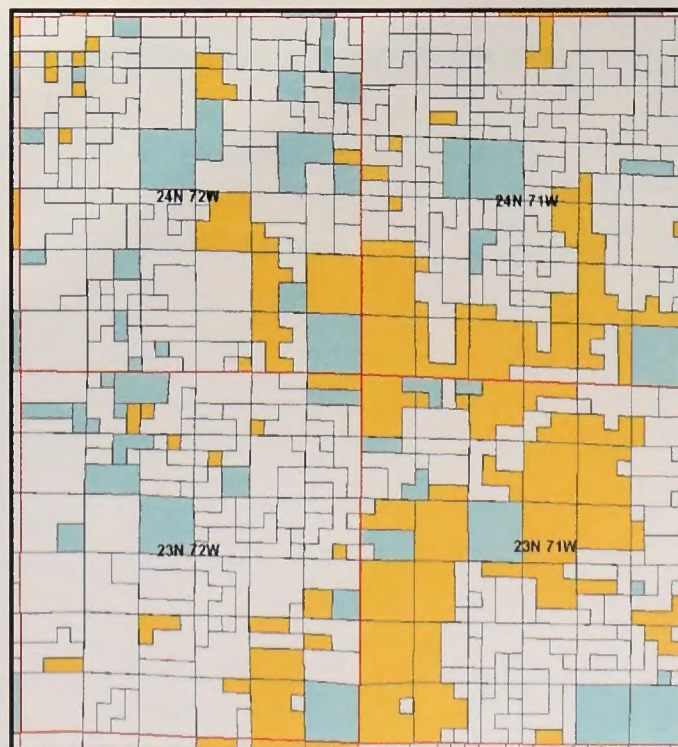
4. The next step involved constructing a series of queries against the U.S. rights data associated with lands that were disposed of by virtue of various title transfers. This query process involved intensive comparison against the attribute tables in the spatial databases. The results of these processes allowed definition of all lands where subsurface oil and gas rights are owned by the United States.

Figure A3-4 illustrates the distribution of subsurface mineral ownership within a four-township area. The parcels shaded gray represent patented lands where the United States has retained rights to the mineral or oil and gas estate.



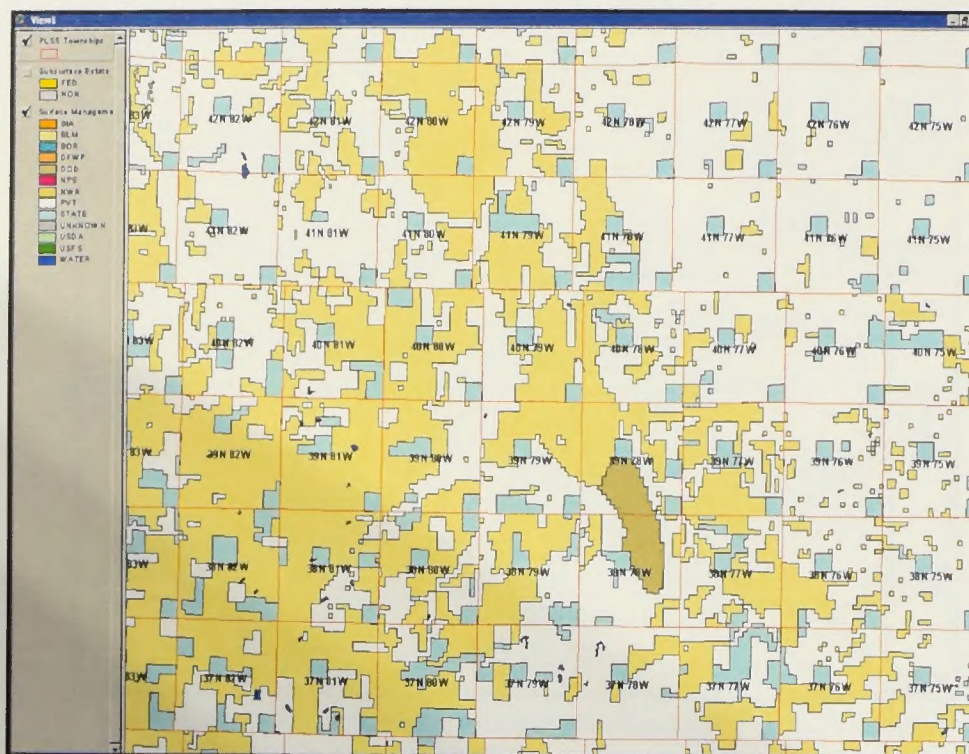
*Figure A3-4 Retained U.S. Rights to Mineral or Oil and Gas Estate*

5. Next, any surface management agencies or state ownership were defined. These determinations were made by completing a series of queries against the ownership fields in the shape files. An example of the results of this query is shown in Figure A3-5, where the parcels shaded blue represent lands that were granted to the State of Wyoming.



*Figure A3-5 Defining Ownership*

The final processing step was to dissolve the individual parcels into ownership categories that define the surface and mineral estates. Figure A3-6 shows the surface management agencies and how land ownership is distributed within an area of the Powder River Basin in Wyoming.



**Figure A3-6 Surface Management View**

In contrast to the surface management view, the mineral estate (shown in Figure A3-7) covers the same area and yields a much different picture. The yellow areas represent lands where the Federal government owns oil and gas rights.



**Figure A3-7**      *Subsurface Oil and Gas Ownership View*

Through the above-described procedure, a detailed assessment of the land status was performed. To facilitate the analytical portion of the project, a simplified version of the status data was created, based on the allocation of the detailed land status to the fundamental Federal surface management agency (i.e., BLM, USDA-FS, etc.)<sup>2</sup>. Maps of the Federal land status for the study areas are presented in Section 2 in Figures 2a through Figure 2e.

The derivation of land status, while complex given the amount of recordation examined, was straightforward in process. However, the following limitations do exist:

The data sets created from the processes described above reflect the legal land descriptions contained in the BLM databases. Case files were not consulted in the process. This procedure did generate error logs, especially if legal land descriptions had not been properly formatted according to BLM's published LR-2000 standards. The errors created in this process are believed to have minimal impact.

If a legal description referenced a small survey lot or tract by number, a nominal location was mapped through a PROCESS that referenced the BLM's LLD file. This file is limited to a 40-acre description and carries a minor degree of generalization in complex areas.

The BLM Case Recordation System is not consistently populated with U.S. rights data. To overcome this, the split estate ownership was established from Case Recordation Data by contacting BLM State and field offices. This process results in a minor degree of generalization.

Some status information derived from GIS coverages was obtained from multiple sources, resulting in the creation of some sliver polygons during the spatial processing and merging of these data.

These are an artifact of the differing sources of data and may be present in certain ownership themes; however, their impact on the analyses is minimal.

The processing of the PLSS data, which are variably sourced, resulted in edge matching across State boundaries. This is believed to have a minimal impact on the analyses.

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<sup>2</sup> The detailed and simplified land ownership databases are presented, by study area, on the CD accompanying this report.



## APPENDIX 4

### LEASE STIPULATION DATA PREPARATION

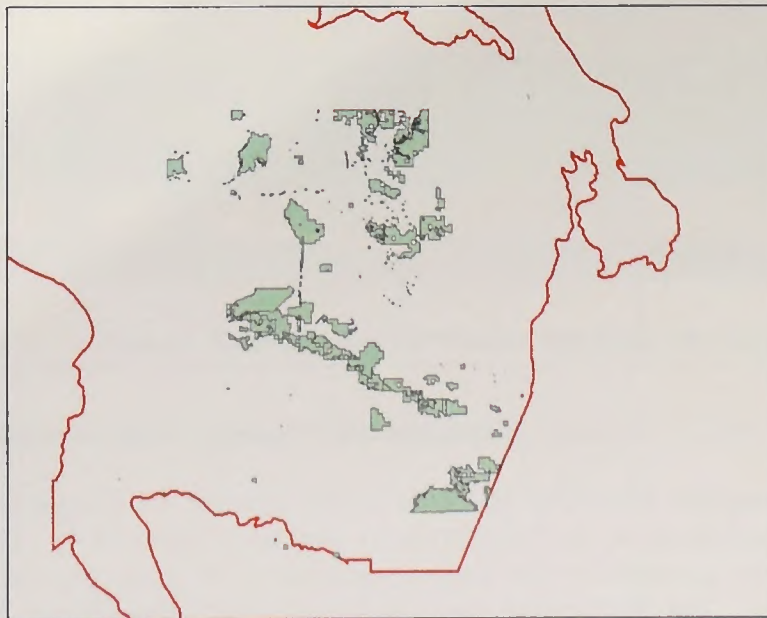
The bulk of the data preparation consisted of data gathering, data digitization, and compilation of the gathered data in a multi-layered GIS format (ESRI shapefiles). Federal Geographic Data Committee Standards (FGDC)-compliant metadata for the resulting GIS layers were also created. GIS coverages from surface management agency land status, stipulations, and the analyses, as well as the associated metadata, are presented on the CD-ROMs accompanying this report.

Where necessary, the shapefiles obtained from the Federal land management agencies were processed using ArcGIS software by matching specific leasing stipulations found in the guidance documents.

The EPCA inventory is limited to those Federal lands within the aggregate resource play boundaries of the five study areas, which are based on geology as defined in the USGS National Assessment of Oil and Gas Resources. The land status and stipulation shapefiles, which correspond to Federal land management agency jurisdiction boundaries, were “clipped” using the GIS to the appropriate study boundary. Some of the shapefiles fell into multiple study areas, so the clipping process was repeated for each area. The attribute tables of the compiled shapefiles were then queried for unique leasing stipulation values. The query results were then saved as separate polygon shapefiles. Each shapefile represents a unique stipulation value.

The following discussion of the specific data preparation steps uses the Paradox/San Juan Basin study area as an example.

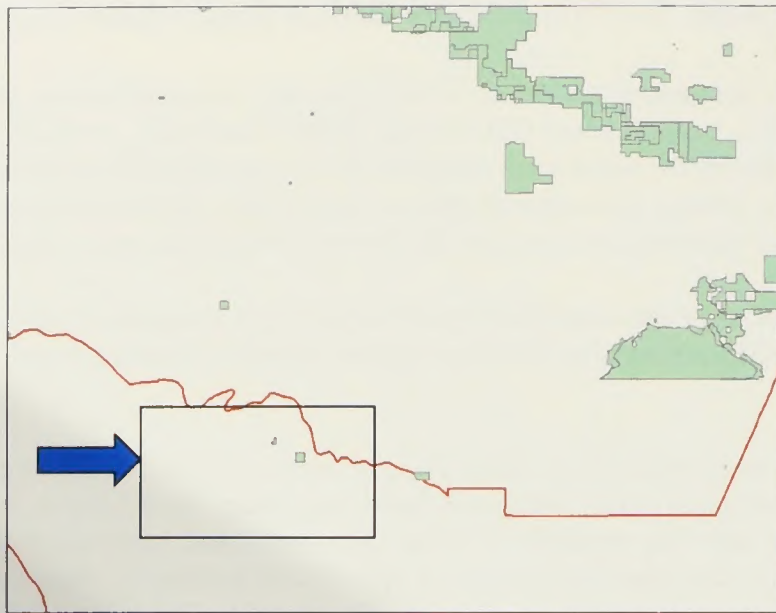
1. The first step entails loading the study area (union of resource plays) boundary shapefile and the compiled stipulation shapefile into ArcGIS (Figure A4-1).



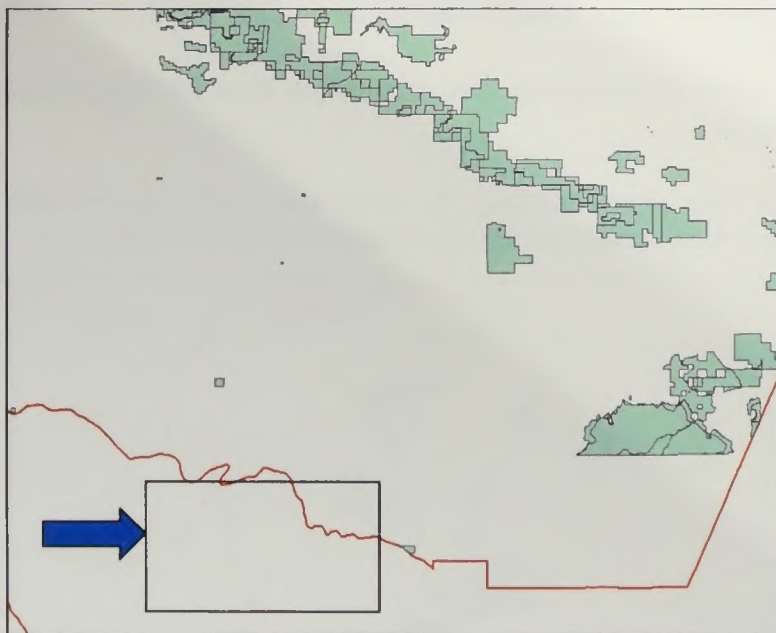
*Figure A4-1 Multi-Stipulation Polygon and Study Area Boundary*

2. The next step in this process is to “clip” or cut the compiled stipulation shapefile to the study boundary. Figure A4-2 shows how this GIS coverage partially falls outside

of the study boundary. Figure A4-3 shows the GIS coverage after it has been clipped.



**Figure A4-2**      *Example of Shapefile Extending Over Study Area Boundary*



**Figure A4-3**      *Example of Shapefile after Clipping to Study Area Boundary*

3. The compiled stipulation shapefile is then queried for unique stipulation attributes values as shown in the ArcGIS Query Builder (Figure A4-4). For this example, all polygons covered by the leasing stipulation “Critical Big Game Habitat” were selected. The highlighted rows in the attribute table (Figure A4-5) show which records are selected. The polygons associated with the selected attributes are highlighted in Figure A4-6 (purple outline).

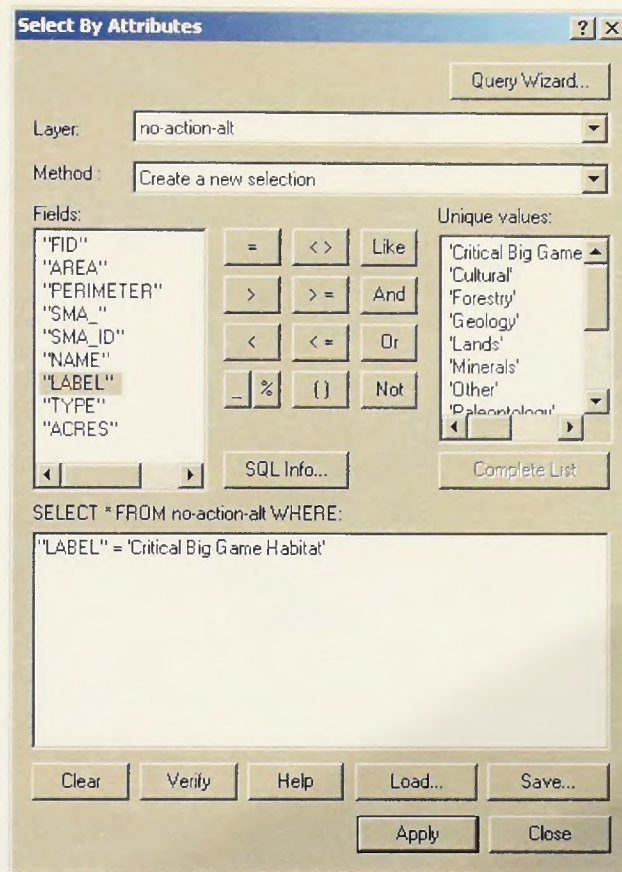


Figure A4-4 Query in ArcGIS for all “Critical Big Game Habitat”

FID	Shape	AREA	PERIMETER	SMA	SMA_ID	NAME	LABEL	T
15	Polygon	0	0.00431	0	0	Historic Homesteads	Cultural	AS
16	Polygon	0	0.00502	0	0	Historic Homesteads	Cultural	AS
17	Polygon	0	0.00433	0	0	Historic Homesteads	Cultural	AS
18	Polygon	0	0.00402	0	0	Historic Homesteads	Cultural	AS
19	Polygon	0	0.0043	0	0	Historic Homesteads	Cultural	AS
20	Polygon	0	0.00454	0	0	Historic Homesteads	Cultural	AS
21	Polygon	0	0.0043	0	0	Historic Homesteads	Cultural	AS
22	Polygon	0.01017	0.84966	0	0	Critical Big Game	Critical Big Game Habitat	BO
23	Polygon	0.00718	1.09157	0	0	Critical Big Game	Critical Big Game Habitat	BO
24	Polygon	0.01717	1.45917	0	0	Critical Big Game	Critical Big Game Habitat	BO
25	Polygon	0.0001	0.05789	0	0	Critical Big Game	Critical Big Game Habitat	BO
26	Polygon	0.00028	0.09199	0	0	Critical Big Game	Critical Big Game Habitat	BO
27	Polygon	0.00033	0.06584	0	0	Critical Big Game	Critical Big Game Habitat	BO
28	Polygon	0.00185	0.33017	0	0	Critical Big Game	Critical Big Game Habitat	BO
29	Polygon	0.00398	0.35978	0	0	Critical Big Game	Critical Big Game Habitat	BO
30	Polygon	0.00177	0.2752	0	0	Critical Big Game	Critical Big Game Habitat	BO
31	Polygon	0.02178	2.50405	0	0	Critical Big Game	Critical Big Game Habitat	BO
32	Polygon	0.00033	0.0225	0	0	Asiabache Station	Preservation	AS
33	Polygon	0.00004	0.00289	0	0	Bald Eagle	T&E Species	AC
34	Polygon	0.00002	0.00162	0	0	Bald Eagle	T&E Species	AC
35	Polygon	0.00187	0.30980	0	0	Asiabache Station	Preservation	AS

Figure A4-5 Attribute Table Showing all “Critical Big Game Habitat” Polygons

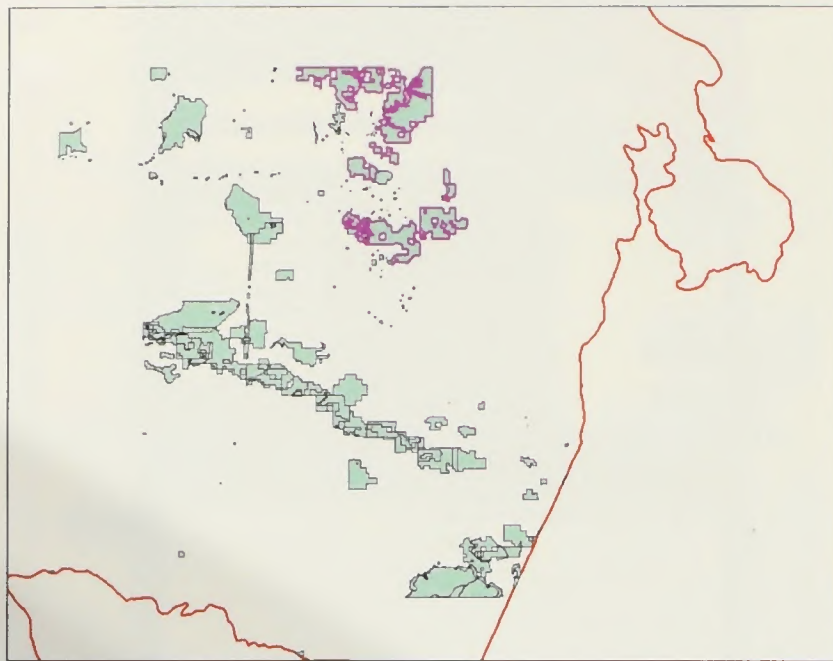


Figure A4-6 Polygons Selected by Query as "Critical Big Game Habitat"

4. Using the ArcGIS function "Create layer from Selected Features," a new shapefile is created that contains only polygons labeled with the attribute "Critical Big Game Habitat" (Figure A4-7). Figure A4-8 shows the new shapefile that is created.

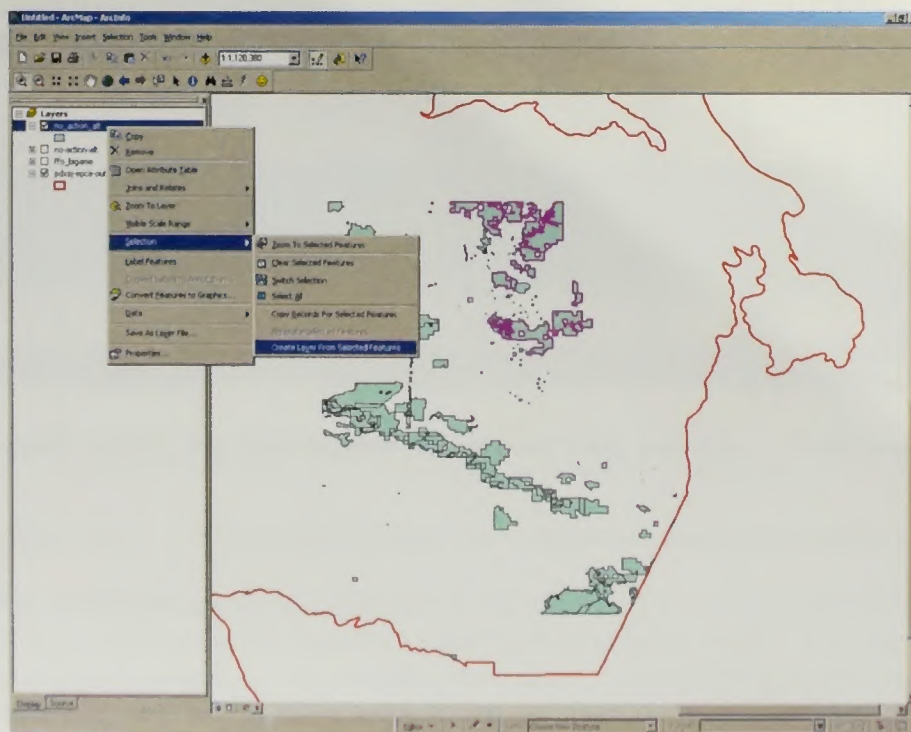
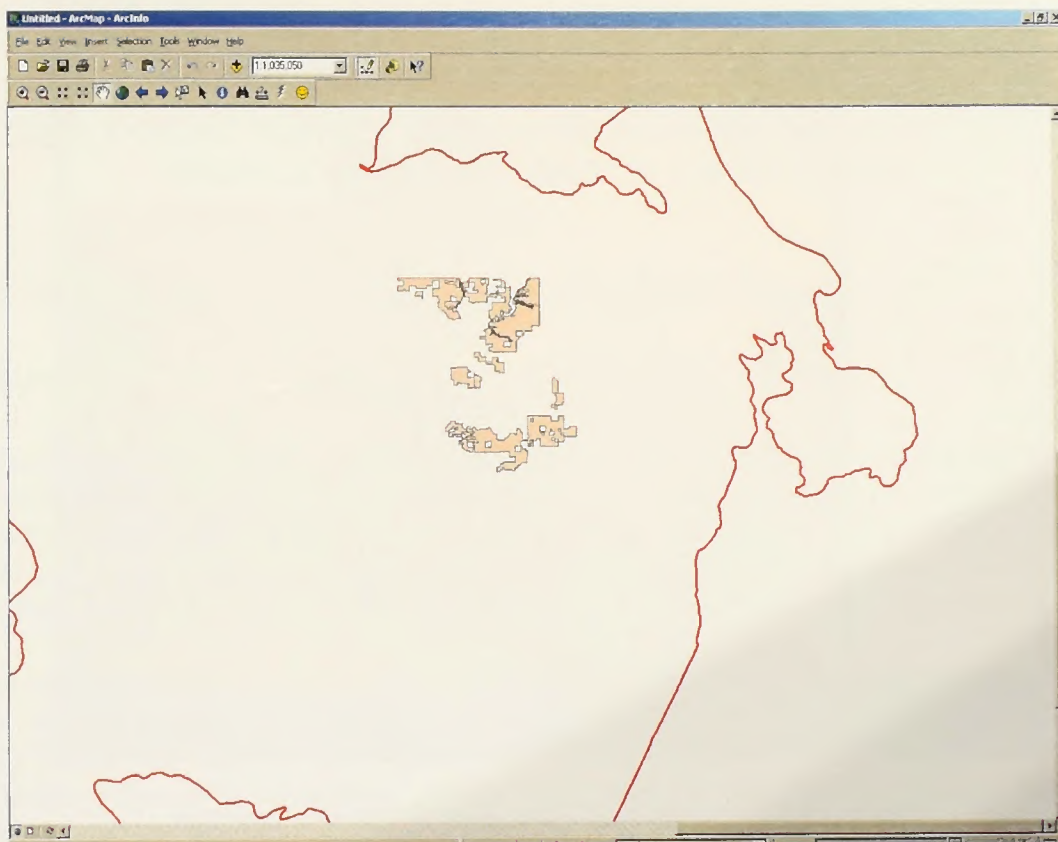


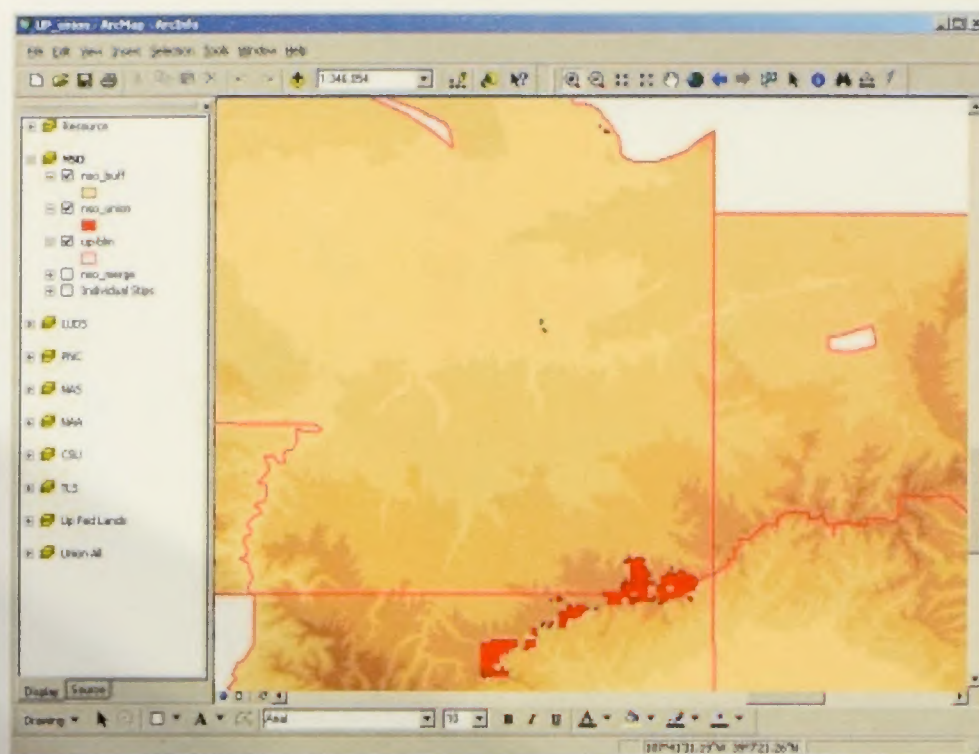
Figure A4-7 Creating New Shapefile from Selected Attributes



**Figure A4-8**      *New Shape File Representing Land with Leasing Stipulation for  
“Critical Big Game Habitat”*

For certain stipulations, such as steep slopes, for which GIS data were not available from the BLM or Forest Service offices, shapefiles were created from available data in conformance with stipulation requirements. For example, a typical steep slope stipulation impacts leasing in areas where slopes exceed 40 percent. Polygon themes were created from slope data derived from USGS 1:24,000 Digital Elevation Models (DEMs). These raster data sets contain elevation information on a 30-meter grid spacing.

The USGS DEMs were first clipped to the BLM or Forest Service jurisdictional area. In situations where more than one agency had the same stipulations, the digital elevation model (DEM) was clipped to the agencies’ combined jurisdictional area. A raster coverage was then created containing slope percentage data as calculated by ArcGIS. This coverage was then queried to isolate the areas covered by the stipulation (i.e., all areas equal to or steeper than 40 percent). The selected raster data was then converted to a vector polygon coverage, and the coverage was coded and attributed as described above. Figure A4-9 shows the creation of steep slope coverages. The 30-meter USGS DEM for this portion of the Uinta Basin is shown in shades of beige. The red theme at the bottom center of the figure represents the polygon shapefile showing areas with a greater than 40 percent slope.



*Figure A4-9      Creation of Steep Slope Restriction Coverages*

Following the above procedures, the GIS shapefiles of the stipulations were coded with their respective descriptions from the various land use plans. These stipulations are listed in Appendix 9.

## APPENDIX 5

# U.S. GEOLOGICAL SURVEY METHODOLOGY FOR THE ASSESSMENT OF UNDISCOVERED OIL AND GAS RESOURCES

By U.S. Geological Survey National Assessment Review Team

## Introduction

The USGS conducts assessments of technically recoverable undiscovered oil and gas resources of the onshore and State waters of the United States. The last comprehensive USGS oil and gas assessment was completed in 1995, and comprises the onshore and State waters portion of 71 geologic provinces (Gautier and others, 1996). In 1999, the USGS initiated a new, six-year plan to produce incremental assessments of the 25 most significant U.S. oil and gas provinces.

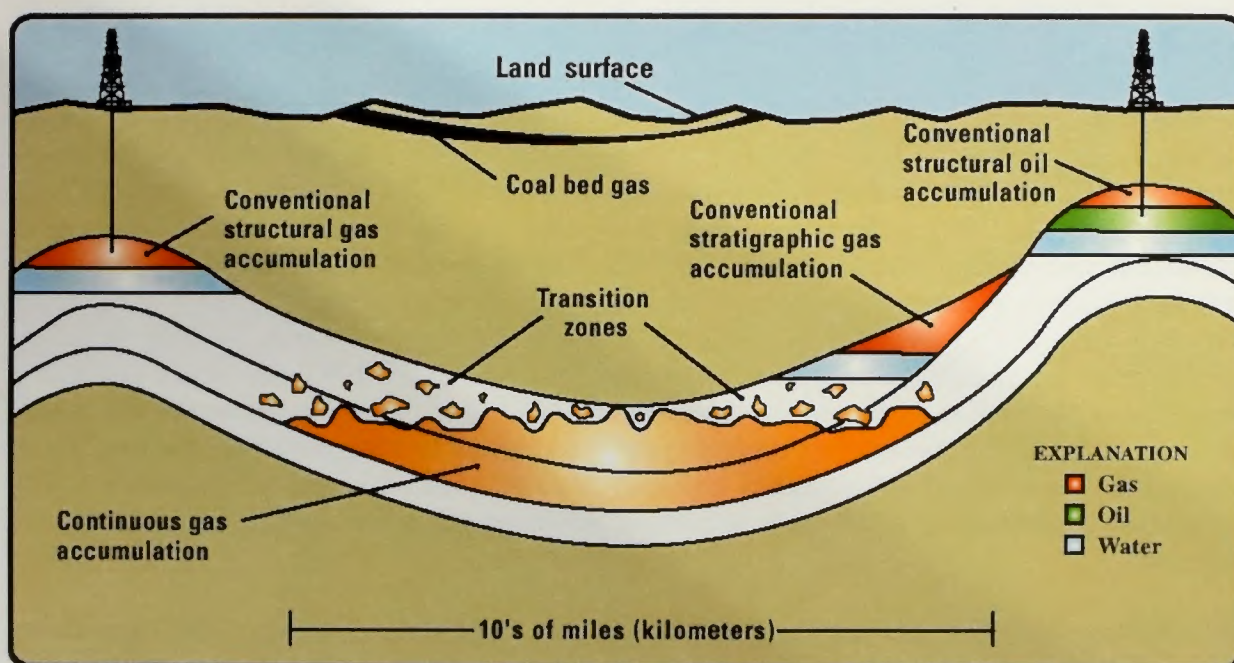
To meet the requirements of Section 604 of the EPCA, the USGS reorganized the priority list for the new re-assessments. For this EPCA report, new assessments were conducted for the Uinta-Piceance Basin, San Juan Basin, Montana Thrust Belt, Powder River Basin, and Greater Green River Basin. The 1995 assessment results were used for the Paradox Basin. The general assessment methodology has not changed from the 1995 assessments; however, some refinements have been made to accommodate increased geologic understanding of the occurrence of resources and more sophisticated means of capturing the range of uncertainty inherent in these variables. For example, the assessment model for continuous resources in the 1995 assessment assumed a homogenous distribution of oil and gas resources in a play. For the new assessments, that model has been replaced with an analysis of geologically controlled sweet spots of production, which demonstrate the geologic heterogeneity common to continuous oil or gas accumulations. The recognition of production sweet spots is a major advancement in the assessment of continuous resources.

This report includes the assessment of undiscovered conventional and continuous (unconventional) oil and gas resources of these resources to surface land ownership categories in the five priority EPCA provinces listed above: Uinta-Piceance Basin, Paradox-San Juan Basins, Montana Thrust Belt, Powder River Basin, and Southwest Wyoming (Greater Green River Basin).

## Terminology

Terminology used in this report reflects standard definitions and usage of the oil and natural gas industry and the petroleum resource assessment community. Several terms have been developed by the USGS for oil and gas assessment purposes (see Glossary in Appendix 2). The 1995 USGS assessment focused on the definition and assessment of geologic *plays*. In the latest USGS assessment, the focus is on understanding total petroleum systems and defining *assessment units* within total petroleum systems. The total petroleum system approach is designed to focus the geologic studies on the hydrocarbon source rocks, processes that create hydrocarbons, migration pathways, reservoirs, and trapping mechanisms. For discussion purposes in this report, the term *play* will be used throughout to represent both *assessment units* and *plays*.

The USGS assesses two main categories of hydrocarbon occurrence: conventional and continuous (Figure A5). Conventional oil and gas accumulations are defined as discrete fields with well-defined hydrocarbon-water contacts, where the hydrocarbons are buoyant on a column of water. Conventional accumulations commonly have relatively high matrix permeabilities, have obvious seals and traps, and have high recovery factors. In contrast, continuous accumulations (also called unconventional accumulations) commonly are regional in extent, have diffuse boundaries, and are not buoyant on a column of water. Continuous accumulations have very low matrix permeabilities, do not have obvious seals and traps, are in close proximity to source rocks, are abnormally pressured, and have low recovery factors. The USGS assessment focused on understanding the geology and occurrence of continuous hydrocarbon accumulations, as the resource potential of these accumulations may be greater than that for conventional accumulations in the U.S. Included in the category of continuous accumulations are hydrocarbons that occur in tight reservoirs, shale reservoirs, unconventional reservoirs, basin-centered reservoirs, fractured reservoirs, coal beds, hydrates, and oil shales.



*Figure A5*      *Conventional vs. Continuous Accumulations*

## Overview of the Oil and Gas Assessment Procedure

The assessment process is based on the characterization of the petroleum geology of each province. The geologists define the geologic elements of the total petroleum systems, and, in conjunction with an analysis of historic oil and gas production and exploration/discovery data, define the oil and gas plays within the provinces. The geologists then develop probability distributions for sizes and numbers of undiscovered conventional accumulations, or numbers of cells and EUR's for continuous accumulations, using all available geologic information and historic oil and gas data. These distributions are then used to generate probability distributions for undiscovered oil and gas resources.

## Role of Geologic Information in the Assessment

The strength of the USGS oil and gas resource assessments is the province geologists' understanding of the petroleum geology of the provinces being assessed. These fundamental geologic studies allow new concepts and hypothetical plays to be incorporated into the assessment of undiscovered resources. A purely statistical approach to an assessment such as discovery process modeling that uses only historical data will overlook any new geologic concepts, models, or hypothetical plays.

The team of geologists develops an understanding of the province petroleum geology using published, proprietary, and original research and data. Studying the total petroleum systems within a province includes: (1) identification and mapping the extent of the major hydrocarbon source rocks; (2) understanding the thermal evolution of each source rock, the extent of mature source rock, and the timing of hydrocarbon generation, expulsion, and migration; (3) estimating migration pathways and all forms of hydrocarbon trapping; (4) modeling the timing of structural development and the timing of trap formation relative to hydrocarbon migration; (5) determining the sequence stratigraphic evolution of reservoirs, and the presence of conventional or continuous reservoirs, or both; and (6) modeling the burial history of the basin and the effect burial and uplift has had on the preservation of conventional and continuous hydrocarbons.

Once the total petroleum systems of the province are known in satisfactory detail, the team of geologists defines oil and gas plays, which represent a synthesis of all geologic information, including production and exploration data. The key component of this analysis is a geologic model for the assessment of each play. The geologic model encompasses all elements of the total petroleum system, and is commonly summarized by a total petroleum system events chart.

## Sources of Oil and Gas Data

Data for domestic oil and gas fields, reservoirs, and wells are derived from commercial databases purchased annually by the USGS. With more than 2.5 million domestic oil and gas wells and 40,000 oil and gas fields, the USGS has opted to purchase the data from commercial vendors rather than attempt to generate a comprehensive database. The oil and gas wells and production databases are now purchased from the IHS Energy Group (2000 a, b). Previous assessments used the predecessors to IHS: PetroROM Production Data (Petroleum Information/Dwights LLC, 1999a) and the Well History Control System (Petroleum Information/Dwights LLC, 1999b). The USGS also relies on the NRG Associates, Inc. Significant Oil and Gas Fields of the United States (NRG Associates, 2001). Data from these commercial databases are subject to proprietary constraints, and the USGS cannot publish, share, or serve any data from these databases. However, derivative representations in the form of graphs and summary statistics can be prepared and presented for each play. The USGS, however, cannot verify the accuracy, completeness, or currency of data reported in commercial databases.

The IHS production database provides oil and gas production data for wells, leases, or producing units (collectively called "entities" in these databases). The IHS oil and gas wells database provides individual well data (including data for dry holes) that include well identification, locations, and information on penetrated and producing formations. Oil and gas field databases provide location, geologic characterization, and oil and gas production data for domestic oil and gas fields and reservoirs.

Additional oil and gas data are obtained, where available, from operators, state agencies, and other government sources, such as the U.S. Department of Energy's Energy Information Administration proprietary files, publications from the former Bureau of Mines, and other sources.

### **Assigning Accumulations and Wells to Plays**

Digital maps of plays are created using a GIS. The oil and gas play boundaries are available at <http://energy.cr.usgs.gov/oilgas/noga>. Digital play maps are used to assign oil and gas wells and accumulations to their respective plays, and these assignments are entered into the databases. Oil and gas accumulations are assigned to only one play. Wells, however, can be assigned to more than one play if they penetrate vertically stacked plays. Oil and gas accumulations and well assignments are reviewed to ensure proper assignments, identify inconsistent data, and examine the need for minor revisions of play boundaries.

Historic production and exploration/discovery data are collected for each play using oil and gas accumulations or well assignments. Types of data retrieved include: (1) known volumes (sum of cumulative production and remaining reserves) of recoverable oil, gas, and natural gas liquids (NGL) of accumulations; (2) discovery dates of accumulations (the year the first reservoir in the accumulation was discovered); (3) monthly production and cumulative production of wells; (4) initial classification and final classification of wells (for example, new-field wildcat, development, producing, abandoned, and so on) of wells; and (5) completion dates of wells.

### **Oil and Gas Production Data**

The historic oil and gas production data are compiled for each play so that the data from discovered accumulations can be used as a guide for potential undiscovered accumulations. For conventional plays, these data include (1) field name, (2) field discovery year or date of completion of the discovery well, (3) known volumes of oil, gas (non-associated and associated-dissolved), and NGL, and (4) depth to the top of each reservoir. All of the production data for conventional assessment units are arranged in terms of oil accumulations and gas accumulations and sorted by size and discovery date for statistical calculations and plotting. A list of new-field wildcat wells and their completion dates is compiled and organized into the number of wells drilled per year for conventional plays. (A new-field wildcat well is an exploratory well drilled at least two miles from a producing field to test a separate trap.) Once organized, the number of wells drilled in a given year is used as a measure of exploration effort. These data are then combined with the production data using the discovery dates of the accumulations and the completion dates of the wells.

Oil and gas production data compiled for each producing well in continuous-type plays include past monthly production of liquids (oil and NGL) and gas (non-associated and associated-dissolved), from which EUR's are estimated using well decline-curve analysis, the date of first production, and depth to the topmost perforation. A list of all wells and completion dates are compiled and organized. However, the number of wells drilled in a given year is not combined with production data, but analyzed separately.

Co-product ratios (GOR; NGL to gas ratio; and LGR) are calculated and major commodities (oil or gas) are identified for each conventional accumulation. Co-product ratios are based on accumulation-level oil, gas, and NGL volumes. Oil and gas accumulations are treated separately;

an oil accumulation is defined as one having a GOR less than 20,000 cubic feet/barrel whereas a gas accumulation has a GOR equal to or greater than 20,000 cubic feet/barrel.

Supplemental data from individual reservoirs within the accumulations include thickness (net and gross), average porosity, average permeability, temperature, pressure, fluid properties (for example, sulfur content of oil, API gravity of oil, non-hydrocarbon gas contents), trap type, drive type, and well spacing. These data are combined with the data from the commercial databases to help refine the geologic interpretations and assessment process.

### **Graphs and Statistics for Conventional Plays**

Two sets of graphs and statistics are generated for conventional plays – one set using known accumulation sizes as of the effective date of the assessment and one set using accumulation sizes that are corrected for anticipated reserve growth (grown accumulation size) within the forecast span of the assessment.

The set of graphs and statistics generated for conventional plays includes sizes and number of accumulations with respect to discovery date and exploration effort, exploration effort through time, size distributions of accumulations, reservoir depth versus discovery date and exploration effort, co-product ratios versus reservoir depth, and a histogram of the API gravity. Accumulations containing less than a specified minimum volume of oil or gas (that is, the smallest accumulation size that is considered in the assessment process) are not included in these graphs or statistics. Counts of new-field wildcat wells are used as a measure of exploration effort for finding new accumulations.

### **Assessment Input for Conventional Plays**

Critical input data for conventional plays are probability distributions for sizes and numbers of undiscovered oil and gas accumulations and co-product ratios. The geologists develop these distributions by synthesizing all petroleum systems information and historic oil and gas data. For hypothetical plays, the geologist may utilize an analog data set for sizes and numbers of discovered fields as a guide to the distributions of sizes and numbers of undiscovered fields in the play or assessment unit being assessed. Geologists provide information on oil and gas quality, range of drilling depths, and range of water depths for future economic analyses.

### **Graphs and Statistics for Continuous-Type Plays**

A set of graphs and statistics comparable to that for conventional plays is generated for continuous-type plays, but the EUR per cell and numbers of tested cells are used rather than accumulation sizes and number of discovered accumulations. Tested cells of less than the specified minimum EUR per cell are not included in these graphs or statistics, and reserve-growth adjustments for cells are not incorporated.

The set of graphs and statistics generated for continuous-type plays includes number of wells drilled through time (all wells as opposed to new-field wildcat wells), probability distributions of EUR, EUR versus production-start year and number of all wells drilled, cumulative EUR versus production-start year and number of wells drilled, cumulative EUR versus depth of the topmost perforation, and GOR versus ranked EUR. All of this information is provided to the assessor as a guide to generating distributions for the assessment of undiscovered resources.

## **Assessment Input for Continuous Plays**

Critical input data for the continuous play assessment model include numbers of cells that have potential to be added to reserves, the EUR distribution for these cells, and the co-product ratios. For hypothetical plays, the geologist may utilize an analog data set for distribution of cell size and for the EUR distribution as guides to the distributions of cell sizes and EUR's of undiscovered area in the play being assessed. The geologist provides information on oil and gas quality, range of drilling depths, and range of water depths for future economic analyses.

## **USGS Assessment Review**

The province geologist must present the geology of the play and the input data to a team of USGS personnel for a formal review. The team consists of geologists, geophysicists, and assessment methodologists with broad expertise in petroleum geology, which together promotes a consistent geological and methodological approach to the assessment. Every aspect of the geology and input data are reviewed, and any changes are incorporated into the input data at this time. Once the input data have been finalized, the input data are ready for quantitative analysis.

## **Calculation of Undiscovered Conventional and Continuous Resources**

The final reviewed assessment input forms are the basis of the quantitative calculations of undiscovered oil and gas resources. For conventional plays, the probability distributions for sizes and numbers of undiscovered accumulations and the co-product ratios provided by the assessor are entered into a Monte Carlo simulator and run for a specified number of iterations to provide distributions of undiscovered oil, gas, and NGL resources. In the 1995 assessment, a Truncated Shifted Pareto Distribution (Gautier and Dolton, 1996) was used for the shape of the curve for the distribution of sizes of oil and gas fields. For the present assessment, a Truncated Shifted Lognormal Distribution is used for this purpose (Charpentier and Klett, 2000).

For continuous plays, the distributions for assessment-unit area, untested percentage of assessment unit area, potential percentage of untested area, and area per cell of untested cells are combined analytically to determine the distribution for number of potential untested cells. The distribution for numbers of potential untested cells EUR per cell, and the co-product ratios are combined using an Analytic Probability Method (Crovetli, 2000) to directly calculate the probability distribution of undiscovered oil and gas resources.

## **Assessment Results**

The results and maps of the resource assessment of more than 90 oil and gas plays for the Uinta-Piceance Basin, Paradox-San Juan Basins, Greater Green River Basin, Powder River Basin, and the Montana Thrust Belt provinces can be downloaded from <http://energy.cr.usgs.gov/oilgas/noga>.

Interim EPCA Report and Assessment Review Team:

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San Juan Basin Assessment:

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Crovelli, R.A., 2000, Analytic resource assessment method for continuous (unconventional) oil and gas accumulations - the "ACCESS" method: U.S. Geological Survey Open-File Report 00-044, 34 p.

Gautier, D.L., and Dolton, G.L., 1996, Methodology for assessment of undiscovered conventional accumulations, *in* 1995 National assessment of United States oil and gas resources--Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS-30, Release 2 (1 CD-ROM).

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NRG Associates, Inc., 1993, 1994, 1999, 2000, and 2001 [includes data current as of December 31, 1992, December 31, 1993, December 31, 1998, December 31, 1999, and December 31, 2000, respectively], The Significant Oil and Gas Fields of the United States: Colorado Springs, Colo., NRG Associates, Inc.; database available from NRG Associates, Inc., P.O. Box 1655, Colorado Springs, Colorado 80901, U.S.A.

Petroleum Information/Dwights LLC, 1999a [includes data current as of December, 1998], PetroROM Production Data: Englewood, Colo., Petroleum Information/Dwights LLC; database now available from IHS Energy Group, 15 Inverness Way East, D205, Englewood, Colorado 80112, U.S.A.

Petroleum Information/Dwights LLC, 1999b [includes data current as of December, 1998], Well History Control System: Englewood, Colo., Petroleum Information/Dwights LLC; database now available from IHS Energy Group, 15 Inverness Way East, D205, Englewood, Colorado 80112, U.S.A.

## APPENDIX 6

### ENERGY INFORMATION ADMINISTRATION PROVED RESERVES ESTIMATION AND FIELD BOUNDARY CONSTRUCTION

#### Summary

The EPCA task of the Reserves and Production Division, Office of Oil and Gas, Energy Information Administration, was to ascertain the relationship of proved reserves of crude oil, natural gas and natural gas liquids to Federal lands located in selected geologic basins of the Rocky Mountain region. This involved attribution of reported and imputed proved reserves to individual fields, development of field boundaries, and relation of the field boundaries and the associated proved reserves estimates to Federal lands. The primary results are presented in multi-layered GIS format accompanied by metadata compliant with the Federal Geographic Data Committee Metadata Standard.

Five sources of data were assembled and conditioned for the project:

- 1) The 2001 Form EIA-23 Reserves Survey, which was the source for the bulk of proved reserves
- 2) The commercially vended IHS Energy Group (IHS) Production Data set, which provided field and reservoir names and 2001 production
- 3) The IHS Well History Data set, which provided the bulk of the individual well locations
- 4) Relevant State web sites that were consulted to augment the IHS data as respects field and reservoir names, locations, and status
- 5) Federal lands boundary data, provided by the Department of the Interior

Several steps were involved in the data assembly and conditioning phase:

- 1) Identifying study area wells, reservoirs, and fields
- 2) Editing and renaming of reservoir and field names to make them consistent from source to source
- 3) Identification and standardization of well types
- 4) Exploration of alternative methods for determining appropriate well buffer sizes
- 5) Testing of alternative methods for the rendering of field boundary polygons
- 6) Merging of the IHS Production data, the IHS Well History data and the Form EIA-23 survey data

To compare the fields and their reserves to Federal lands it was necessary to construct a boundary for each field. Placement of appropriate buffers around individual wells, followed by their union, was relied on to create reasonable field boundaries. Buffer size was based on well spacing as determined from measurements of the latitude and longitude of an individual well's spud point relative to those of neighboring wells within the same reservoir. Rules were developed to determine on the basis of these measurements which standard well spacing should be used for each reservoir, as well as to handle exceptional cases. Field boundary polygons were generated using ESRI's ArcGIS Version 8.2 software using the standard well spacing-based buffers assigned to each reservoir. A Visual Basic application was written to automate this process. The software performed these main steps:

- 1) Selection of all wells and buffer distances with a specific field
- 2) Creation of a buffer around each well in the field using the assigned "buffer distance"
- 3) Unioning of the buffers in each field to dissolve inner boundaries of overlapping buffers
- 4) Outputting of a boundary polygon, sometimes more than one polygon, for each individual field
- 5) Areal comparison the field boundary polygons to the Federal lands polygons resulting in output of the Federal lands fraction of the total field area

Proved reserves estimates submitted on the 2001 Form EIA-23 survey were used in the proved reserves estimation process as-reported. For those fields in which only some of the operators reported on Form EIA-23, the weighted average reserves-to-production ratio of those which reported was multiplied by the production of non-reporting operators to impute the latter's proved reserves. To impute proved reserves for those fields in which no operator had reported on Form EIA-23, regression equations were developed from the reported observations that were used to estimate proved reserves for these typically small fields. The portion of proved reserves associated with Federal lands within the field was then computed using the Federal lands fraction and each field was assigned to a proved reserves size class sufficiently narrow to be useful for EPCA purposes while at the same time broad enough to ensure confidentiality of each Form EIA-23 respondent's proprietary proved reserves estimates.

For the entire study area, proved Federal lands liquid reserves (crude oil plus condensate) were estimated to be 53.6 percent of total proved reserves; individual basins ranged from 0.0 to 68.9 percent. Similarly, for the entire study area, proved Federal lands gas reserves were estimated to be 60.1 percent of total proved reserves; individual basins ranged from 0.0 to 79.4 percent. Also for the entire study area, Federal lands proved BOE reserves were estimated to be 59.5 percent of total proved reserves; individual basins ranged from 0.0 to 78.6 percent.

## The Study Areas

The basins targeted in this initial EPCA study and the States and counties pertinent to them are listed in Table A6-1. Final Federal lands boundaries for the study areas were received from the USGS on July 17, 2002. All wells in the listed States and counties for which location information (in the form of latitude and longitude coordinates) was available were plotted along with the study area boundaries. Wells not located within the study area boundaries were then discarded.

*Table A6-1: Targeted Basins and Their State and County Affiliations*

### Montana Overthrust Belt

<u>State</u>	<u>Counties</u>
Montana	Beaverhead, Broadwater, Cascade, Deer Lodge, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis & Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Park, Pondera, Powell, Ravalli, Sanders, Silver Bow, Teton

### Paradox-San Juan Basin

<u>State</u>	<u>Counties</u>
Colorado	Archuleta, Dolores, La Plata, Mesa (part), Montezuma, Montrose (part), San Miguel, San Juan
New Mexico	Cibola, McKinley, Rio Arriba, San Juan, Sandoval
Utah	Emery (part), Garfield, Grand (part), Iron, Kane, Piute, San Juan, Sevier (part), Washington, Wayne

### Powder River Basin

<u>State</u>	<u>Counties</u>
Montana	Bighorn, Carter, Custer, Powder River, Rosebud, Treasure
Nebraska	Sioux
South Dakota	Custer, Fall River
Wyoming	Campbell, Converse, Crook, Johnson, Natrona, Niobrara, Sheridan, Weston

### Greater Green River (SW Wyoming) Basin

<u>State</u>	<u>Counties</u>
Colorado	Eagle, Garfield (part), Moffat (part), Rio Blanco (part), Routt
Utah	Daggett, Summit
Wyoming	Carbon, Fremont, Lincoln, Sublette, Sweetwater, Teton, Uinta

### Uinta-Piceance Basin

<u>State</u>	<u>Counties</u>
Colorado	Delta, Garfield (part), Gunnison, Mesa (part), Moffat (part), Montrose (part), Ouray, Pitkin, Rio Blanco (part)
Utah	Carbon, Duchesne, Emery (part), Grand (part), Juab, Sanpete, Sevier (part), Uintah, Utah, Wasatch

Note: “(part)” indicates that more than one basin applies to a county

## The Data Sources

Five principal sources of data were used for this study:

- a. The **2001 Form EIA-23 Survey** files which contain field production and proved reserves estimates as reported by the largest operators.
- b. **IHS Production CD's** which contain crude oil, AD gas, NA and condensate production at the well (for gas) or lease (for oil) level.
- c. **IHS Well History CD's** which contain well history records. The well data include well spud point location (latitude and longitude thereof generated by Tobin International, Ltd.), field names, producing formation(s), and well type at the time of completion.
- d. Many of the Rocky Mountain States have **official websites** that provided supporting data on locations and field names. Links to the websites used in this study are listed below.

**Appendix 6**  
**EIA Proved Reserves Estimation**  
**and Field Boundary Construction**

Colorado web mapper	<a href="http://eogceweb.state.co.us/maps/">http://eogceweb.state.co.us/maps/</a>
Colorado data	<a href="http://oil-gas.state.co.us/">http://oil-gas.state.co.us/</a>
Montana web mapper	<a href="http://www.bogc.dnrc.state.mt.us/website/mtcbm/webmapper_intro.htm">http://www.bogc.dnrc.state.mt.us/website/mtcbm/webmapper_intro.htm</a>
Montana data	<a href="http://bogc.dnrc.state.mt.us/jdplIntro.htm">http://bogc.dnrc.state.mt.us/jdplIntro.htm</a>
New Mexico web mapper	<a href="http://geoinfo.nmt.edu/resources/petroleum/poolmaps.html">http://geoinfo.nmt.edu/resources/petroleum/poolmaps.html</a>
New Mexico data	<a href="http://octane.nmt.edu/data/">http://octane.nmt.edu/data/</a> , <a href="http://www.emnrd.state.nm.us/ocd/data.htm">http://www.emnrd.state.nm.us/ocd/data.htm</a>
South Dakota maps (not interactive)	<a href="http://www.sdgs.usd.edu/digitalpubmaps/testholewells">http://www.sdgs.usd.edu/digitalpubmaps/testholewells</a> <a href="http://testholewellsmapne.html">testholewellsmapne.html</a>
South Dakota data	<a href="http://www.state.sd.us/denr/DES/Mining/Oil&amp;Gas/producti.htm">http://www.state.sd.us/denr/DES/Mining/Oil&amp;Gas/producti.htm</a>
Utah web mapper	<a href="http://dogm.nr.state.ut.us/oilgas/MAP%20SEARCH/map_search.htm">http://dogm.nr.state.ut.us/oilgas/MAP%20SEARCH/map_search.htm</a>
Utah data	<a href="http://dogm.nr.state.ut.us/oilgas/qref_Find_data.htm">http://dogm.nr.state.ut.us/oilgas/qref_Find_data.htm</a>

- e. **Federal lands** boundary data provided by the Department of the Interior.

**Limitations Imposed by the Available Data Sources**

A variety of shortcomings and flaws in the presently available data sources impose unavoidable limitations either on what can be done or on the achievable level of accuracy. Chief among these are:

- 1) Aside from the Form EIA-23 survey data base, which contains standardized field name spellings and corresponding standardized field codes, field and reservoir names are all too frequently non-standard as respects content and/or spelling. This makes accurate automated -- often even manual -- matching of field and well records across data sources difficult at best and sometimes impossible. While the standardized field codes are assigned and supported by EIA, most field names and their spellings are assigned by State agencies. Much of the problem is rooted in the fact that, over the past two-plus decades, many of the producing States have trimmed the resources devoted to this task, with the result that the extant staffs are overburdened and large backlogs exist. When reporting well or production information for a field on which the State has not yet acted, a field's operator is free to use any name it fancies, spelled however it wishes.

An additional causative factor was the demise of the American Association of Petroleum Geologists' Committee on Statistics of Drilling, which for many years performed an essential initial and subsequently recursive quality control function relative to the Nation's well statistics and field and reservoir identities. Staffed by experienced industry personnel whose services were "voluntarily" contributed by the firm they worked for, the Committee was disbanded in the wake of the 1986 oil price collapse. Its files were turned over to the American Petroleum Institute (API) which for many years attempted to maintain and update them absent the "in-the-field" quality control that the Committee had provided. When API's budget also diminished, and the last of the API staff familiar with the well files retired, they were transferred to two competing commercial data vendors for continued maintenance and updating. Both recipient firms are now subsumed in IHS.

- 2) Well misclassification is a perennial problem. For the most part, it is caused by insufficient recursive quality control. For example, a new well may initially be classified as a wildcat well, which by definition has discovered a new field. Subsequent drilling of extension wells in this or an adjacent field may, over time (sometimes over decades) connect the two adjacent fields, at which point both fields will shift to the field name of the earliest discovered of the two. This and similar sorts of things happen frequently, but that fact often never filters backward in time,

i.e., in this case to re-classification of the wildcat well type to extension or even development status.

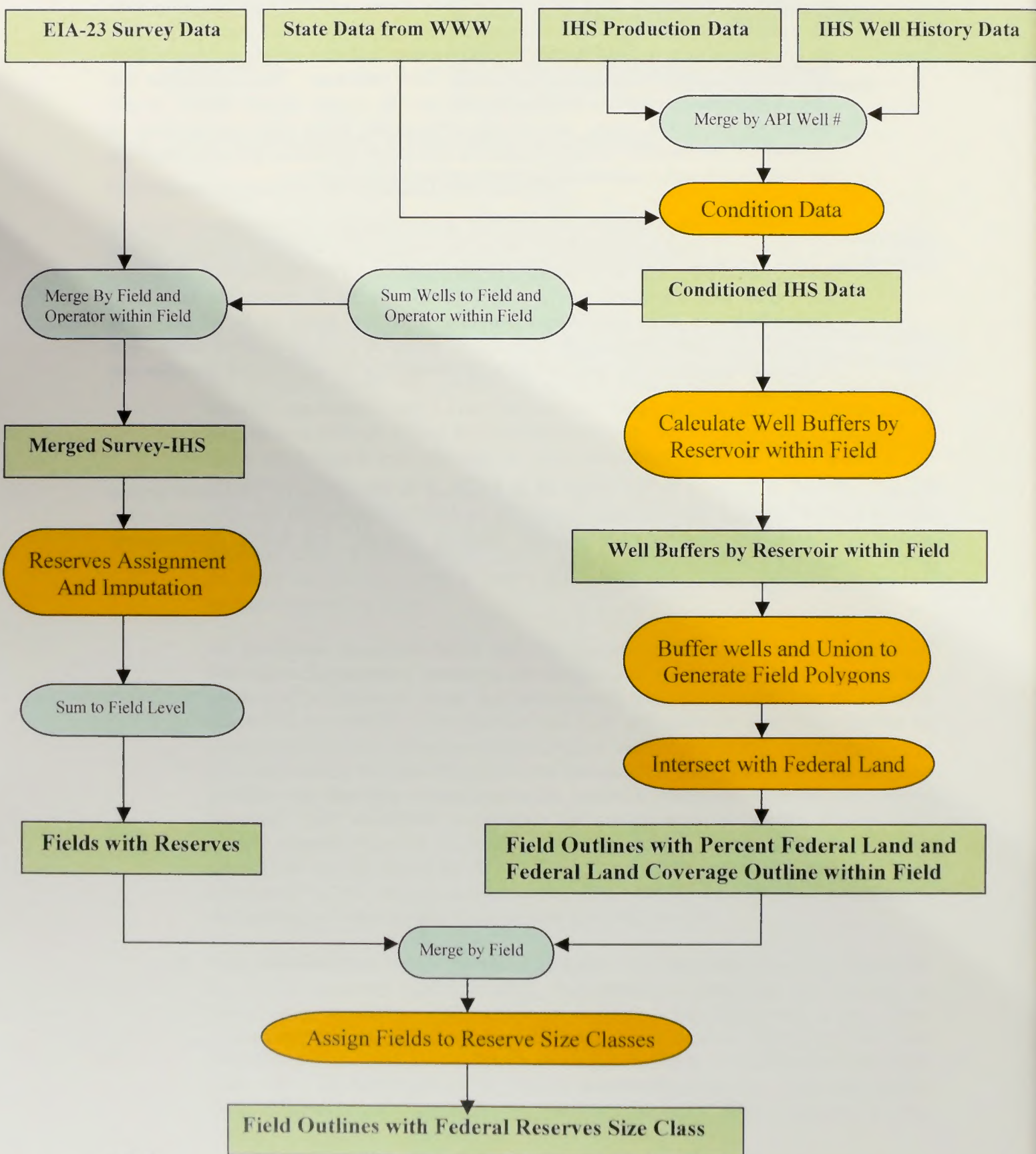
- 3) With the notable exception of fields located on the Federal Outer Continental Shelf, the Federal government does not as a rule have access to subsurface data other than the usually incomplete well-specific data resident in the IHS Well History file. We do not have access to field operators' seismic data and interpretations, nor to their surface and subsurface geologic maps, nor to their well logs. Such information has historically been treated as proprietary and private in the United States. In the context of the EPCA study, lack of this information limits what can be done as respects the construction of field boundaries to a purely geometric approach based on the buffering of well locations around their surface spud points.

The resultant field boundaries are therefore approximations, the accuracy of which in the absence of adequate subsurface information depends to a greater or lesser extent, from case-to-case, on the professional judgment of RPDs experienced petroleum geologists and engineers as to what appears to be a reasonable boundary. *Collectively the field boundaries provided here are likely to be of sufficient accuracy for policy formulation as respects access to Federal onshore lands. But in specific instances, they may not be good enough for the application of policy and regulation.*

### General Process Overview

Figure A6-1 is a flow chart of the major steps followed in estimation of field-level proved reserves (on the left-hand side) and the construction of field boundaries (on the right-hand side), as well as their merger into the final principal reserves product. The following discussion provides details for each of the indicated steps.

*Figure A6-1 Proved Reserves Estimation and Field Outline Development  
Process Flows*

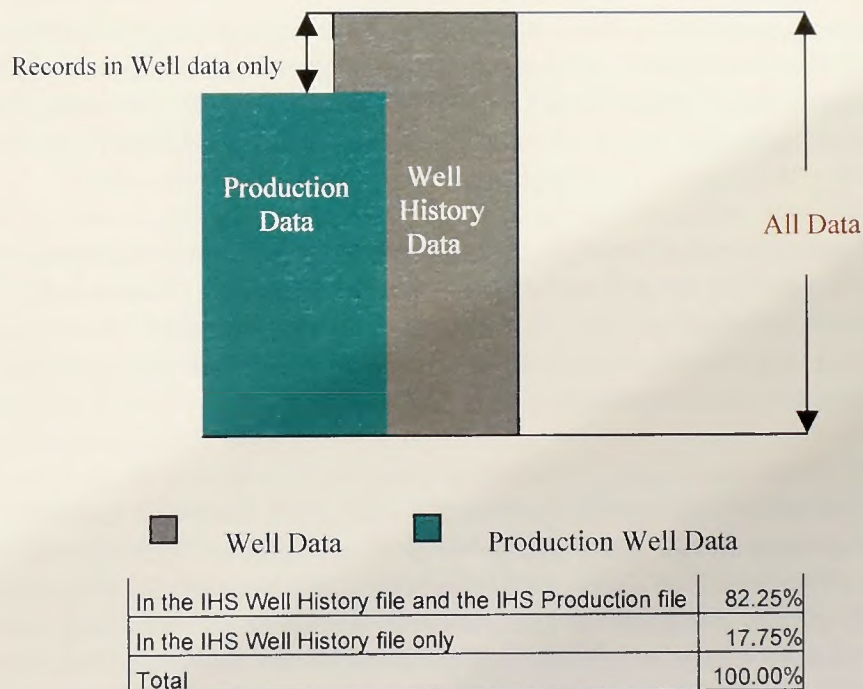


## Data Conditioning

### Merging of the IHS Production and Well History files

This step combined the annual production data with well location and well type. The API well number, present in both files, was the key to this merging process. Figure A6-2 shows the percentage of wells that were matched by API number and the percentage that was unique to the Well History file.

**Figure A6-2 Matching of Wells by API Number and Source**



IHS Well History records that did not match with IHS Production records were most often dry holes, injection, or storage wells. These were discarded. To create valid field boundaries, only oil and gas wells were retained, whether or not they had recorded 2001 production data. The following rules and procedures were developed and used to merge the files:

- a. Preparation of spud point location information (well latitude and longitude at the surface)

The location information in the IHS Well History file is Tobin's most accurate coordinates. They were therefore used when available. If location information was not present in the Well History file, the location information in the Production file was used. If location information was not available in either dataset, the well record was deleted from the data used for field boundary construction. These well records were, however, retained for merger with the Form EIA-23 data base because, even absent a location, these wells could at the field level be rolled up with other wells in the same field for which location information was available.

b. Editing/Renaming of Fields and Reservoirs

As previously noted, variations in field and reservoir names and spellings are common in the commercially-vended data files and some State sources. Names were altered when necessary to make them as consistent as possible. The problem of missing names also had to be addressed, often through contact with State personnel. To achieve better field boundaries it was assumed that the buffers created for wells should be calculated on a reservoir level and that the field boundary would then be constructed by unioning of the reservoirs in the field.

Names carried on the IHS Production file were used when they were available. Otherwise, names from the IHS Well History file were used.

If a record appeared not to have a legitimate *field* name, (e.g., 'UNDESIGNATED', 'UNKNOWN', 'WILDCAT'), a concatenation of Basin and State was used to replace it (e.g. new field names like "PRB\_WY", "UPB\_CO", "UPB\_UT", etc, were created). When records appeared not to have a legitimate *reservoir* name, (e.g., 'UNKNOWN', 'UNKNWN', 'WILDCAT'), "UNNAMED" was used as reservoir name.

If a reservoir name was abbreviated, the full reservoir name was assigned. If a reservoir name was augmented by a layer/zone/horizon modifier (e.g. "Dakota A," "Dakota B") the modifier was removed (e.g. all were changed to "Dakota"). Most records did not have horizon information available so the zone name was used instead as the best available data for reservoir naming.

Some field names were changed based on information obtained from State websites and conversations with State agency personnel. The CBM reservoir and field names were especially affected by the State agencies. For example, as development progressed in Wyoming's Powder River Basin (PRB) the State initially classified wells into fields using a system originally designed for application to conventional reservoirs and fields. The result was usually related to pre-existing field names for deeper conventional oil and gas reservoirs. In apparent belated recognition that the CBM in the PRB is really resident in a whole coal field, they now assign all CBM wells in the basin to the field "PRB," i.e., the wells are assigned to a field comprising the entirety of a producing coal seam (see <http://wogcc.state.wy.us/coalres.cfm> for a list). After conversations with geologist Gary Strong of the Wyoming Oil & Gas Conservation Commission, it was decided that for this study all wells in the PRB with a producing coal reservoir name or which had the IHS attribute "CBM" = yes would be reclassified into the field "PRB\_CBM\_WY". An exception to this procedure was the Fort Union formation where, per Strong, most of the current wells are CBM completions but a few are conventional oil or gas. Thus Fort Union wells were not put into "PRB\_CBM\_WY" unless "CBM" = yes or the word "coal" was in present in the reservoir name.

c. Identification of Well Types for Later Buffering

Deciding which wells to include in the buffering process was critically important to the construction of field boundaries. All wells with type = oil or gas in the IHS Production file were kept. If wells were identified as a dry hole, a CO<sub>2</sub> producer, or an injection well in the IHS Production file, but were identified as an oil or gas well in IHS Well History file, the well type was reclassified to oil or gas. If well records came from IHS Well History file only, the many well types were grouped into four classes: Oil, Gas, Dry hole,

and Injection. Following final assignment of the well type, only the oil and gas wells were retained for input to the buffering process.

### **The Construction of Well Buffers**

The procedure used to generate well buffers consisted of several development and application steps:

#### **a. Testing of Alternative Procedures**

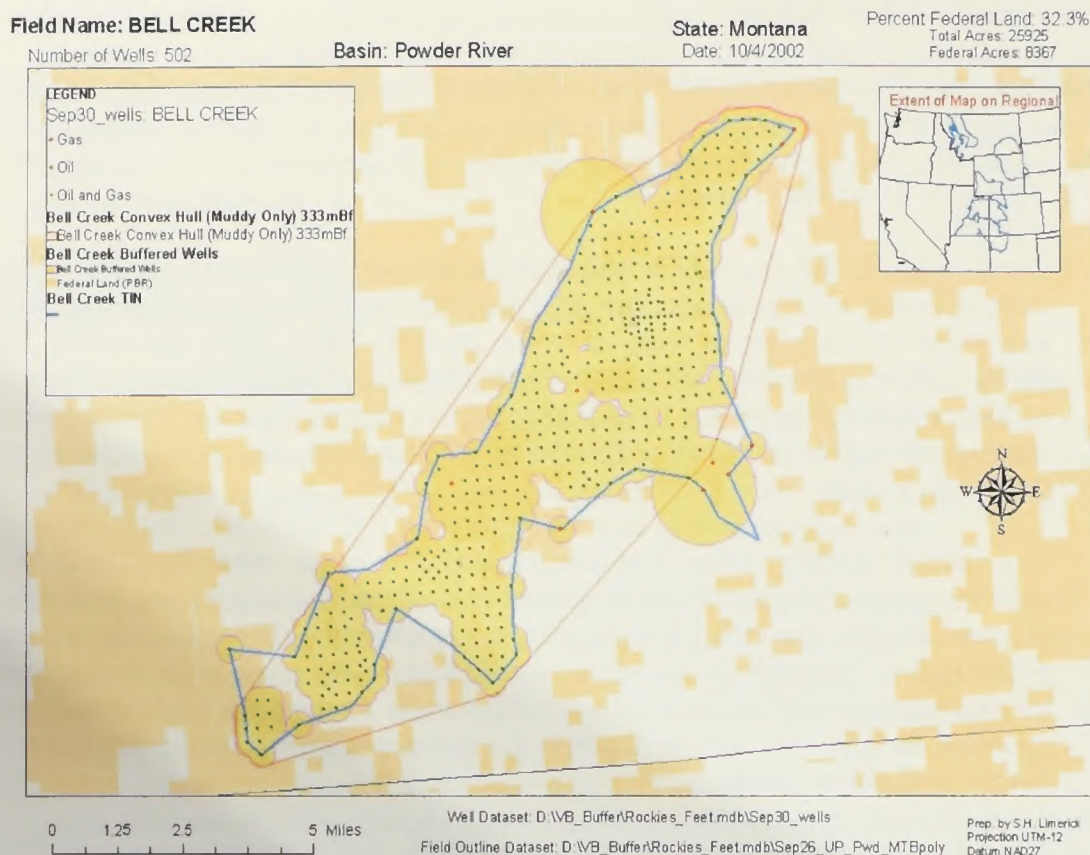
Creation of oil and gas field boundaries was accomplished using ArcGIS. The first method tested was the convex polygon method, which draws a minimum-bounding polygon around a group of wells such that all of the outer angles are convex. While this technique is fine for a structurally simple field, such an oval-shaped anticline with a uniform hydrocarbon-water contact, many fields have an irregular boundary owing to stratigraphic and/or structural complexity. For these fields a convex hull overestimates productive acreage.

The second method tested was the triangular irregular network (TIN). A TIN represents a set of points (wells) as a set of contiguous, non-overlapping triangles. The triangles are then unioned into one polygon for the entire field. This method has the advantage of being able to include a z-value such as thickness or perforated interval. Its disadvantage is that the maximum edge length for triangle construction must be specified field-by-field, which made it too laborious for a project with almost 2000 fields boundaries to build.

The method ultimately used for construction of the field boundaries was to buffer each well in a field with a circle. The radius of the circle was determined by analysis of the spacing pattern for each reservoir in the field. The buffer polygons were then unioned into a single field boundary polygon record for each field. Given the time constraints on the EPCA project, this method was selected because it most effectively utilizes the different reservoir spacing patterns within a field and is relatively easy to perform on a large data set.

Figure A6-3 shows Bell Creek Field with the field boundaries created using each of the three methods described above. The convex hull boundary shown does not include all of the field's wells, only those in the Muddy reservoir.

**Figure A6-3** *Bell Creek Field, Powder River Basin, Wyoming, Showing Alternative Field Boundaries*



b. Determination of Nominal Well Spacing and the Assignment of Buffer Radii

An analysis of the distances between wells in a reservoir, calculated from their spud point locations, was used to assign a standard well spacing unit to each reservoir. Nearest neighbor inter-well separation distances were calculated separately for oil wells and gas wells. The upper and lower bounds of observed spacing ranges are shown in the two left-hand columns of Table A6-2. The corresponding nominal standard well spacings (a geometric distribution) and buffer radii are shown in the two right-hand columns. The 75th percentile (P75) of the observed inter-well distance distribution was taken to be the observed inter-well distance. This statistic was selected because, as judged by the Reserves and Production Division of the EIA (RPD) project team, it yielded the best match to nominal spacings in an extensive set of map trials. If the P75 distance fell within the corresponding interval shown in the two left-hand columns of the table then corresponding nominal spacing was selected and its buffer size was initially assigned to every well in the reservoir.

Inter-Well Distance		Nominal Spacing Unit (acres)	Corresponding Buffer Radius (feet)
Lower Bound (feet)	Upper Bound (feet)		
0	277	1.25	233
277	392	2.5	330
392	555	5	467
555	785	10	660
785	1110	20	933
1110	1570	40	1320
1570	2220	80	1867
2220	3140	160	2640
3140	4440	320	3734
> 4440		640	5280

**Table A6-2. Interwell Distance Ranges, Nominal Standard Well Spacings, and Buffer Radii**

c. Well Buffer Construction Rules

Rules for the assignment of buffers were created to handle reservoirs that did not, for whatever reason, readily yield a nominal spacing. They are based on well types and well counts.

1. For oil reservoirs, the maximum spacing allowed was 160 acres, i.e. a buffer radius of 2,640 feet (exceptions are listed below).
2. If the reservoir had between 1 and 10 oil wells or the reservoir name was 'UNNAMED', a spacing of 160 acres was assigned.
3. For gas reservoirs the maximum spacing allowed was 640 acres, i.e. a buffer radius of 5,280 feet (for exceptions, see below).
4. If the reservoir had only 1 gas well or the reservoir was named 'UNNAMED', a spacing of 640 acres was assigned.
5. For coal bed methane wells a spacing of 160 acres was assigned, i.e. a buffer radius of 2,640 feet (exceptions are listed below).
6. If the oil well count / (oil well count + gas well count) ratio was less than or equal to 5% and if the oil well spacing was greater than the gas well spacing, the oil well spacing was set to the gas well spacing; otherwise, the original oil well spacing was retained.

7. If the ratio of gas well count/(oil well count + gas well count) was less than or equal to 5%, the gas well spacing was set to the oil well spacing for the field or reservoir; otherwise, the original gas well spacing was retained.

d. Exceptions to These Rules

Altamont-Bluebell-Cedar Rim Field (three names for different parts of same physical field), Uinta Basin, Utah:

The P75 calculated buffer radius for the main Green River and Wasatch reservoirs ranges from 320-640 acres. Because production is oil, the default maximum 160-acre buffer was used initially, resulting in numerous isolated polygon rings. According to Montgomery and Morgan (1998, *American Association of Petroleum Geologists (AAPG) Bulletin* 82:6:1113-1132), the major portion of this field was developed on 320-ac spacing for the fractured Green River and Wasatch reservoirs. Thus, an exception was made in this field and 320-acre spacing was assumed for the buffers (3,734 feet buffer radius).

Puerto Chiquito West Field, San Juan Basin, New Mexico:

The P75 calculated buffer radius for the main Mancos reservoir is 640 acres. Because the production is oil, the default maximum 160-acre buffer was used initially, resulting in numerous isolated polygon rings. Spacing rules for the field specify 320-acre units due to the excellent reservoir communication in the fractured Mancos, according to Gorham et al (1979, *AAPG Bulletin* 63:4:598-607. Thus, 320-acre spacing was assumed for buffer construction (3,734 feet buffer radius).

Blanco Field, San Juan Basin, New Mexico:

This field ranks third within the study area as respects total number of wells. It has 8,669 wells, of which 8,498 are Mesa Verde Formation gas completions. The P75 calculated buffer distance of 2130 feet for the Mesa Verde falls in the uppermost range of 1570'-2220' for 80-acre units. At that default spacing, the resultant product shows numerous small gaps between the buffers. The largest fields (in numbers of wells and reserves) such as Blanco are so much larger than the average field that they warrant making of an exception if the default buffer size does not appear to be appropriate. Therefore, 160-acre spacing was assumed (2,640 feet buffer radius).

Fruitland Coal Reservoir, Basin Field, San Juan Basin, New Mexico:

The default radius of 160 acres was overridden on the basis of results of consultations with individuals familiar with the field. 320 acre spacing was assigned, i.e., the buffer radius is 3,734 feet.

### **The Construction of Field Boundaries**

A SAS file containing the oil and gas well data labeled with field name attribute "Field" and reservoir name attribute "Reservoir" was imported into ArcGIS as a dBase (.dbf) file. The wells were then plotted and converted to a geodatabase feature class. The coordinate system used was geographic, decimal degrees, NAD27.

Visual Basic for Applications (VBA) code was written within ArcGIS to provide an automated procedure for creation of polygonal field boundaries from buffered wells. The principal steps performed were:

- Select the "field name" attribute and "buffer distance" attribute from the well file
- Select all wells with the first "field name" encountered
- Create a buffer around each selected well using "buffer distance"
- Union the buffers
- Dissolve the barriers between overlapping buffers
- Iteratively perform the above steps for each unique "field name"
- Output a polygon feature class with one polygon (often consisting of multiple polygon rings) for each field
- Convert to a shapefile

### **Calculation of the Federal Lands Fraction within a Field's Boundary**

The Federal land ownership coverages provided by the Department of the Interior (one coverage per basin) were utilized. A definition query of "Minerals" = 'Fed' was used to exclude private and state land within the coverages. An automated procedure was developed to calculate the fraction of federal land and acres of federal land within each oil and gas field polygon. It:

- Intersected the federal land coverages with the field polygons
- Populated two columns in the field boundary polygon table: "FractionFedLand" and "Fed\_Acres."

In the process of calculating the fraction of federal land in the PRB, a "non-simple geometry" error was encountered. The only way to work around this was to eliminate some of the very small slivers of non-federal land in the PRB coverage. While such slivers are present in all five federal land coverages, they only caused problems in the PRB. These are likely not real gaps in federal ownership. Rather, they are most probably the result of merging land parcels from different sources and/or with different projections. The ELIMINATE command was used to merge narrow slivers of non-federal land smaller than 0.5 acres into adjacent federal land polygons. The resultant coverage was visually checked against the original to insure that no non-sliver land parcels were eliminated. After this was done, the calculation proceeded without error.

### **Review and Quality Control of the Resulting Maps**

An additional part of the VBA routine not included in the above list of steps automated the construction of field boundary maps for quality checking purposes. The maps displayed the wells in the field and the field boundary polygon. They also showed selected field attributes such as State, basin, and percent Federal land.

To quality control the resultant buffers at a more detailed level, boundaries were also constructed at the reservoir level to determine whether the buffer sizes appeared to be appropriate in fields that had multiple reservoirs. Numerous fields were checked in this fashion to verify that the buffering rules produced a reasonable field boundary.

The final field-level buffers and fraction of federal land calculations were checked by inspection of approximately 150 field maps which covered all fields that had more than 300 wells or more than 500,000 barrels-of-oil equivalent proved reserves per the 2001 Form EIA-23 survey.

Appendix 6  
EIA Proved Reserves Estimation  
and Field Boundary Construction

Figure A6-4 provides an example of the quality control maps.

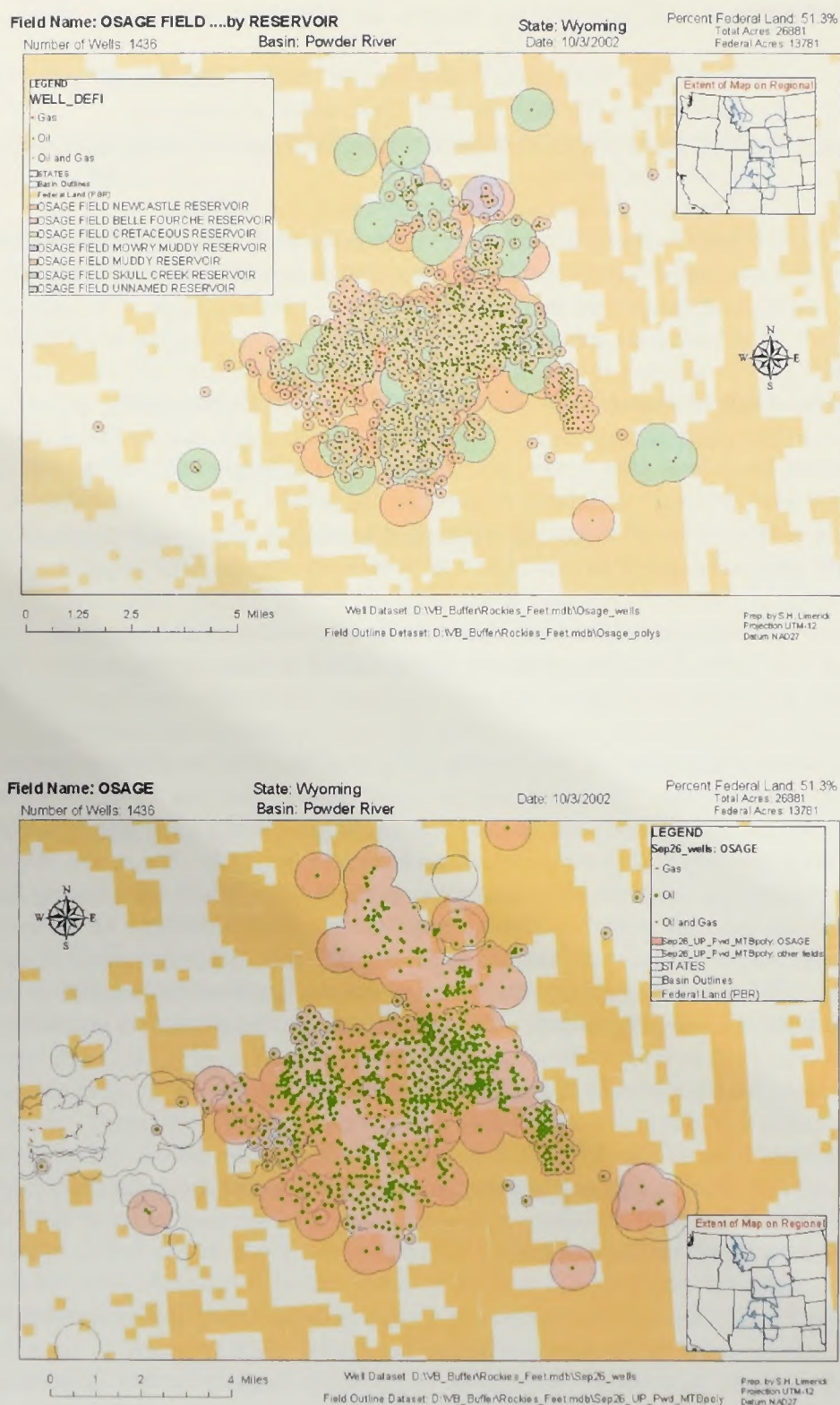


Figure A6-4 Osage Field, Powder River Basin, Wyoming, Showing Buffers by Reservoir (top) and the Field Boundary Resulting from their Union (bottom)

## Field-Level Proved Reserves Estimation

The conditioned IHS well history and production data were summed to the field/operator level and then merged with the by-field proved reserves estimates reported on Form EIA-23 by the largest operators.

Of the 753 field/operator combinations, only 40 (about 5%) could not be matched to the IHS data. Since they could not be matched, they were not mappable owing to lack of location information; their relationship to federal lands is unknown. The portion of total proved reserves contributed by these unmatched fields was very small -- about 1 percent.

Of the 713 field/operator combinations that matched with the IHS data, 398 (about 56%) had all operators in the field reporting. The proved reserves estimates submitted for these fields were used as-reported.

Of the 713 field/operator combinations that matched with the IHS data, 315 (about 44%) had part of their proved reserves reported by the surveyed operators. The remainder of these fields' proved reserves was estimated by RPD. Imputation of proved reserves was accomplished by assigning the weighted average reserves-to-production ratio of the reporting operators to the non-reporting operators. The non-reporting operators' production volumes, taken from the IHS data, were multiplied by this ratio to impute proved reserves for the non-reported portion of these fields.

Proved reserves imputation was also necessary for the remaining 542 fields that had recorded 2001 production, but whose operators were not required to submit Form EIA-23. Although these fields constitute a sizeable fraction of the total fields in the study areas, their proved reserves are only a small portion of total proved reserves, less than 4%. Predictive regression equations were developed to estimate the proved reserves of these fields, as follows:

### a. Development of Regression Equations

The proved reserves estimates and corresponding production data reported on the 2001 Form EIA-23 were used to develop least squares regression equations quantitatively descriptive of the relationship between two. The equations were then used to impute proved reserves for the 542 fields whose operators were not required to complete a Form EIA-23, based on their IHS production data.

Four equations were developed using SAS statistical software, one each for oil, associated-dissolved gas, nonassociated gas, and condensate. The form of the equations is:

$$\log_e (\text{Proved Reserves}) = a + b \log_e (\text{Production})$$

The resulting parameters, the number of proved reserves and production pairs each is based on (n), and the goodness of fit statistics ( $r^2$ ) are provided in Table A6-3.

Product	n	a	b	r <sup>2</sup>
Crude Oil	460	1.4725	1.0924	0.90
Associated-Dissolved Gas	208	1.6646	1.0237	0.93
Nonassociated Gas	672	1.6559	1.0687	0.84
Condensate	294	1.9140	1.0030	0.73

*Table A6-3 Regression Equations for the Estimation of Non-Reported Reserves*

b. Assignment and Imputation of Proved Reserves

When operators reported both production and proved reserves on Form EIA-23, the reported volumes were used. When one or more operators reported for a field but one or more other operators did not report, a weighted average reserves to production ratio was calculated for the reporting operators and multiplied by the missing operators' IHS production to estimate their proved reserves. When a field had no reporting operators, the regression equations shown above were used to impute reserves based on the IHS production data for the field. The final step was to sum the reported and imputed proved reserves to obtain the total proved reserves estimate for the field.

Crude oil proved reserves were then summed with proved condensate reserves to yield proved liquid reserves. Similarly, proved associated-dissolved gas reserves and proved nonassociated gas reserves were summed to yield total proved gas reserves. Last, a gas-to-oil ratio of 6000 cubic feet per barrel was used to convert proved gas reserves to their oil equivalent, which was then summed with proved liquid reserves to yield proved barrel-of-oil-equivalent reserves.

c. Reserves Classification

In order to sufficiently protect the proprietary proved reserves data submitted to EIA, each field was placed into a reserves class, by product, per the following classification scheme:

Class Number	Proved Liquid Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 Mbbl liquid
2	Greater than 10 but less than 100 Mbbl liquid
3	Greater than 100 but less than 1000 Mbbl liquid
4	Greater than 1000 but less than 10000 Mbbl liquid
5	Greater than 10000 Mbbl liquid

Class Number	Proved Gas Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 MMcf gas

4	Greater than 10 but less than 100 MMcf gas
5	Greater than 100 but less than 1000 MMcf gas
4	Greater than 1000 but less than 10000 MMcf gas
5	Greater than 10000 but less than 100000 MMcf gas
6	Greater than 100000 MMcf gas.

Class Number	Proved BOE Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 MBOE
2	Greater than 10 but less than 100 MBOE
3	Greater than 100 but less than 1000 MBOE
4	Greater than 1000 but less than 10000 MBOE
5	Greater than 10000 but less than 100000 MBOE
6	Greater than 100000 MBOE

Note: M=1,000; MM=1,000,000; bbl=barrel; cf=cubic feet

### **Merging of Proved Reserves Classes with Field Boundaries and Fraction of Federal Land**

A GIS file was then produced that contains the intersection of the Federal land coverages with the field boundaries. Owing to the existence of multiple federal land parcels within each field boundary, the resultant boundary polygons were then dissolved on the attribute "field" to union the data into one polygon record per field. A table with the reserve classes by field (range 0 to 6) and the field name was then joined to the dBase file associated with the field boundary shapefile. The latter was then converted to coverage format and thence to interchange file format (.e00).

### **Summary of Results**

GIS is clearly the information conveyance method of choice where both analysis of Federal lands policy and regulations and their application are concerned. The primary proved reserves result is therefore a GIS layer containing field boundary polygons attributed with field name and a proved reserves size class for each field product. Unfortunately, none of that detailed information can be usefully conveyed on a piece of paper this size. You have to use a GIS workstation to view it and a wide-format printer to print it at a size where detail can be distinguished. Therefore, in lieu of such a close look at the reserves results, basin-by-basin summary statistics are provided in Table A6-4.

Appendix 6  
EIA Proved Reserves Estimation  
and Field Boundary Construction

Basin	Number of Fields	Total Liquid Reserves (Mbbbl)	Federal Land Liquid Reserves	Percent	Total Gas Reserves (MMcf)	Federal Land Gas Reserves	Percent	Total BOE Reserves (Mbbbl)	Federal Land BOE Reserves	Percent
<i>Paradox-San Juan</i>	250	174,193	53,103	30.5	20,653,622	11,033,357	53.4	3,616,464	1,891,996	52.3
<i>Uinta-Piceance</i>	180	254,329	142,495	56.0	7,181,669	3,779,755	52.6	1,451,274	772,454	53.2
<i>Greater Green River</i>	281	177,362	122,234	68.9	12,703,038	10,081,667	79.4	2,294,535	1,802,512	78.6
<i>Powder River</i>	543	193,456	110,783	57.3	2,398,604	927,738	38.7	593,223	265,406	44.7
<i>Montana Thrust Belt</i>	1	1	0	0.0	0	0	0.0	1	0	0.0
<i>Total</i>	1,255	799,341	428,616	53.6	42,936,933	25,822,517	60.1	7,955,497	4,732,368	59.5

*Table A6-4 Summary of 2001 Federal Lands Proved Reserves by Study Area*

Another notable result involves the hypothesis that:

- 1) on-average, and
- 2) owing to the existence of stipulations and other impediments to drilling on Federal lands beyond those customarily associated with private leases,

Even within the boundaries of the study area's producing fields, the well density would be lower on the Federal lands than on the non-Federal lands.

The well density on Federal lands within study area's fields was found to be 103.5 acres per well, or 6.19 wells per square mile (640 acres). The well density on the non-Federal lands within the study area's fields was found to be 96.5 acres per well, or 6.63 wells per square mile. This result supports the hypothesis.

## APPENDIX 7

### GIS METHODOLOGY

Following are further descriptions of how Federal lands were categorized into the ten categories referred to in table 2c in Section 2.4.1 and a detailed description of the GIS methodology used.

Table A7-1 shows the “No Leasing Pending Land Use Planning or NEPA Compliance (NLA/LUP)” jurisdictions within the EPCA inventory area.

FS or BLM jurisdiction	Comments
Ashley NF	Northern unit only
Big Horn NF	
Bitterroot NF	Areas east of of Highway 191
Bridger-Teton NF	
Custer NF	
Dillon, MT BLM Field Office	
Dixie NF	
Fish Lake NF	
Flathead NF	
Gallatin NF	
Gunnison, CO BLM Field Office	
Kootenai NF	
Lewis and Clark NF	Western portion only
Lolo NF	
Rio Grande NF	Medicine Bow portion only
Routt-Medicine Bow	
Wasatch-Cache NF	Unmapped western portions only
Uinta NF	

**Table A7-1**      ***Jurisdictions Classified as NLA/LUP***

Table A7-2 shows how agency jurisdictions were used to categorize lands for this inventory.

Federal Land Management		Categorization	Level
Bureau of Land Management	BLM	Subject to stipulations	
Bureau of Reclamation	BREC	Subject to stipulations	
Department of Agriculture*	USDA	No Leasing (Administrative), general category (NLA)*	3.
Department of Defense**	DOD	No Leasing (Administrative), general category (NLA)**	3.
Federal Split Estate	SPLIT	Subject to stipulations	
Fish and Wildlife Service	FWS	No Leasing (Administrative), general category (NLA)	3.
Forest Service	FS	Subject to stipulations	
National Park Service	NPS	No Leasing (Statutory/Executive Order), (NLS)	1.
Federal Land Use Designations			
Inventoried Roadless Areas	IRA	Subject to stipulations	
National Conservation Areas	NCA	No Leasing (Statutory/Executive Order), (NLS)	1.
National Monuments	NM	No Leasing (Statutory/Executive Order), (NLS)	1.
National Recreation Areas	NRA	No Leasing (Statutory/Executive Order), (NLS)	1.
National Wildlife Refuges	NWR	No Leasing (Statutory/Executive Order), (NLS)	1.
Special Designated Areas	SDA	No Leasing (Statutory/Executive Order), (NLS)	1.
Wilderness Areas	WILD	No Leasing (Statutory/Executive Order), (NLS)	1.
Wilderness Reinventory Areas	WRA	No Leasing (Administrative), general category (NLA) for offices listed in next table; otherwise subject to stipulations	3.
Wilderness Study Areas	WSA	No Leasing (Statutory/Executive Order), (NLS)	1.

\* Ft. Keo Agricultural Experimental Station, MT, only

\*\* Except for the Naval Petroleum Reserve, Casper Field Office, which is subject to stipulations

**Table A7-2 Federal Land Categorization**

Jurisdiction	Comments
Ashley NF	
Farmington NM BLM Field Office	
Glenwood Springs CO BLM Field Office	
Grand Junction CO BLM Field Office	Uinta/Piceance Study Area
Grand Mesa /Uncompahgre /Gunnison NF	
Gunnison CO BLM Field Office	
Kemmerer WY BLM Field Office	
Lander WY BLM Field Office	
Little Snake CO BLM Field Office	GGR Study Area
Manti La Sal NF	
Moab CO BLM Field Office	
Monticello CO BLM Field Office	
Pinedale WY BLM Field Office	
Price UT BLM Field Office	
Rawlins WY BLM Field Office	
Rock Springs WY BLM Field Office	
Routt-Medicine Bow NF	
Uinta NF	
Uncompahgre CO BLM Field Office	Uinta/Piceance Study Area
Vernal UT BLM Field Office	
White River CO BLM Field Office	
White River NF	

**Table A7-3 Jurisdictions with Wilderness Reinventory Areas (WRAs)  
Classified as NLA**

Jurisdiction	Comments
Cedar City UT BLM Field Office	Spring Creek Canyon only
Durango CO BLM Field Office	
Glenwood Springs CO BLM Field Office	
Grand Junction CO BLM Field Office	
Grand Mesa /Uncompahgre /Gunnison NF	
Little Snake CO BLM Field Office	
Price UT BLM Field Office	
Uncompahgre CO BLM Field Office	
Vernal UT BLM Field Office	

**Table A7-4**      ***Jurisdictions with Citizen's Proposal Areas (CPAs) Classified as NLA***

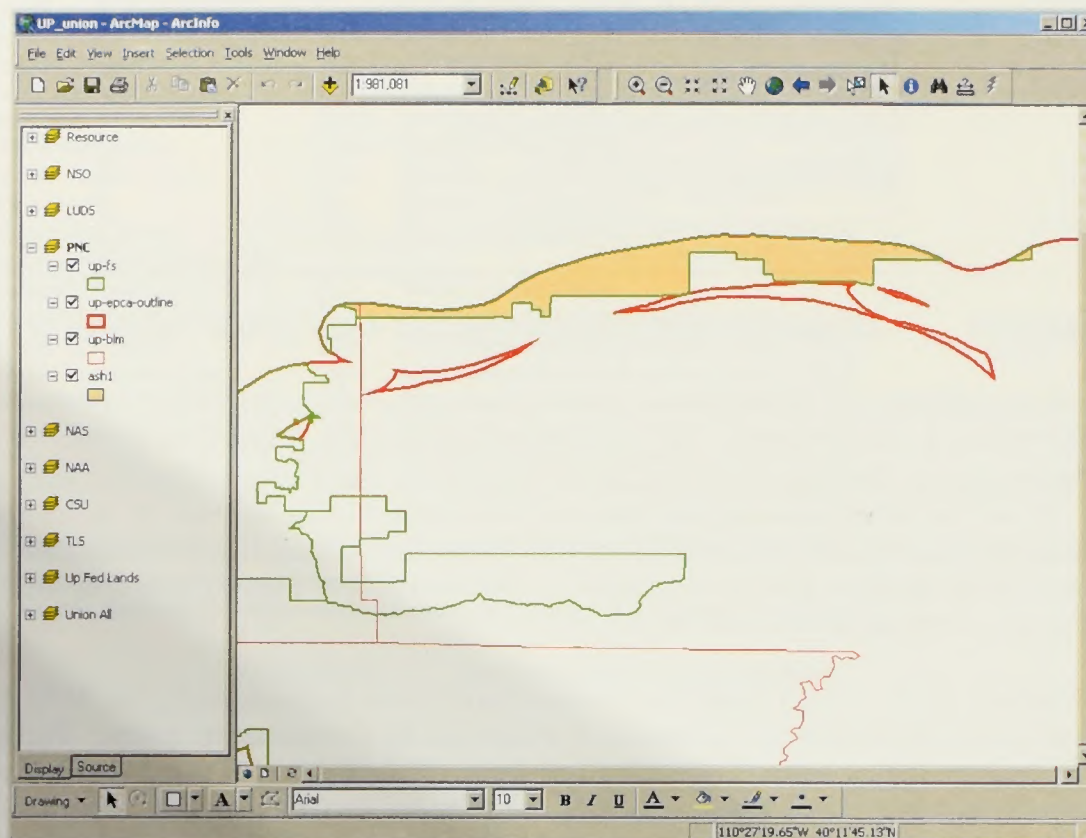
National Forests affected by the Roadless Areas Conservation Rule (36 CFR 294) were considered available for leasing in this inventory. The rationale for this decision is that as of the date of this report, implementation of the Roadless Rule has been enjoined by the Federal District Court of Idaho.<sup>12</sup> However, if current litigation upholds this rule, it could highly restrict or make inaccessible approximately 6.1 million acres within the study areas. For this reason, leases offered and/or issued in areas covered by the Roadless Rule have attached to them a Notice to Lessees informing them that all or part of the lease is within an area covered by this rule.

Citizens' Proposal Areas (CPAs) located on Federal land, primarily managed by the BLM in Utah and Colorado, are places which have been proposed as wilderness by environmental groups. The treatment of CPAs differs by state and by office (Table A7-4). In Utah, offices that have CPAs individually determine their treatment with respect to oil and gas leasing. In Colorado, the CPAs are generally considered NLA unless the area under consideration has been explicitly examined as part of a particular BLM Field Office's planning process.<sup>13</sup>

GIS files were available to define most of the access categories; however, for the NLA/LUP category, they had to be created. In these situations, the administrative boundary (such as a National Forest) was extracted from the surface ownership data and the resultant polygon was then attributed as NLA/LUP. For example in Figure A7-1, the national forests in the western Uinta Basin are shown in green. The beige area represents the Ashley National Forest (northern unit), which is categorized as NLA/LUP.

<sup>12</sup> Idaho vs. Dombeck CV01-11-N-EJL (D.C.Id. 2001 Kootenai Tribe of Idaho et al. vs. Dombeck). Colorado and Alaska have joined Idaho; Utah has also filed.

<sup>13</sup> BLM, Colorado State Office, Instruction Memorandum No. CO-97-044.



**Figure A7-1**      *Creation of NLA/LUP Shapefiles*

### *Stipulation Exceptions*

Sometimes exceptions to stipulations are granted for valid reasons. For example, for a crucial elk winter range timing limitation, an exception may be granted if seasonal conditions (e.g., an early spring and snowmelt) are such that the elk have moved out of and are not using the general areas during a particular year. Because records of exceptions to lease stipulations were not available, BLM and USDA-FS field personnel were asked to determine, based on their experience, which lease stipulations were granted exceptions for drilling and how often. The exception factors thus determined are shown by jurisdiction in Table A7-6.

Lease stipulations, particularly timing limitations, can overlap. Where exception factors overlap, the cumulative effect is calculated by multiplying the overlapping factors (from Table A7-6). This calculation implicitly assumes that exceptions for multiple stipulations would likely not be obtained for a given area. For example, cumulative effects of excepted stipulations for the Greater Green River study area are computed as shown in Table A7-7. The application of these exception factors is described below in the section titled “Analytical Modeling of Federal Lands and Resources.”

Jurisdiction	Exceptions to stipulations				Sleep slopss	Bald Eagle Winter Roost	Calving and Fawning	Antelope Fawning	City of Rifle Water-shed	Sensitive Resources	Soils, Watershed	Sedimentation (roads)	Comments
	Big Game Winter Range	Raptors	Sage Grouse										
Buffalo WY BLM Field Office		25%	25%										Uinta/Piceance Study Area GGR Study Area
Carson NF	10%											10%	
Casper UT BLM Field Office	25%	25%											
Durango CO BLM Field Office	50%	50%			50%				100%				
Glenwood Springs CO BLM Field Office													
Glenwood Springs CO BLM Field Office	20%	30%	20%							30%			
Grand Junction CO BLM Field Office	70%			15%									
Kemmerer WY BLM Field Office	30%	50%	50%										
Lander WY BLM Field Office	20%	30%	20%										
Little Snake CO BLM Field Office	20%	30%	20%										
Manti La Sal NF				50%		80%							GGR Study Area Paradox/San Juan Study Area Uinta/Piceance Study Area Uinta/Piceance Study Area GGR Study Area
Miles City MT BLM Field Office	50%	50%	10%										
Missoula MT BLM Field Office	20%	20%		15%									
Moab UT BLM Field Office	70%						70%				70%		
Pinedale WY BLM Field Office	50%	40%	40%										
Rawlins WY BLM Field Office	20%	30%	20%										
Rock Springs WY BLM Field Office	30%	25%	20%										
Routt-Medicine Bow NF	20%	30%	20%										
Uncompahgre CO BLM Field Office	50%	50%			50%								
Uncompahgre CO BLM Field Office	10%	10%											
White River CO BLM Field Office	80%	25%											
White River CO BLM Field Office	20%	30%	20%										
White River NF						50%							

**Table A7-6 Stipulation Exception Factors List by USDA-FS and BLM Office**

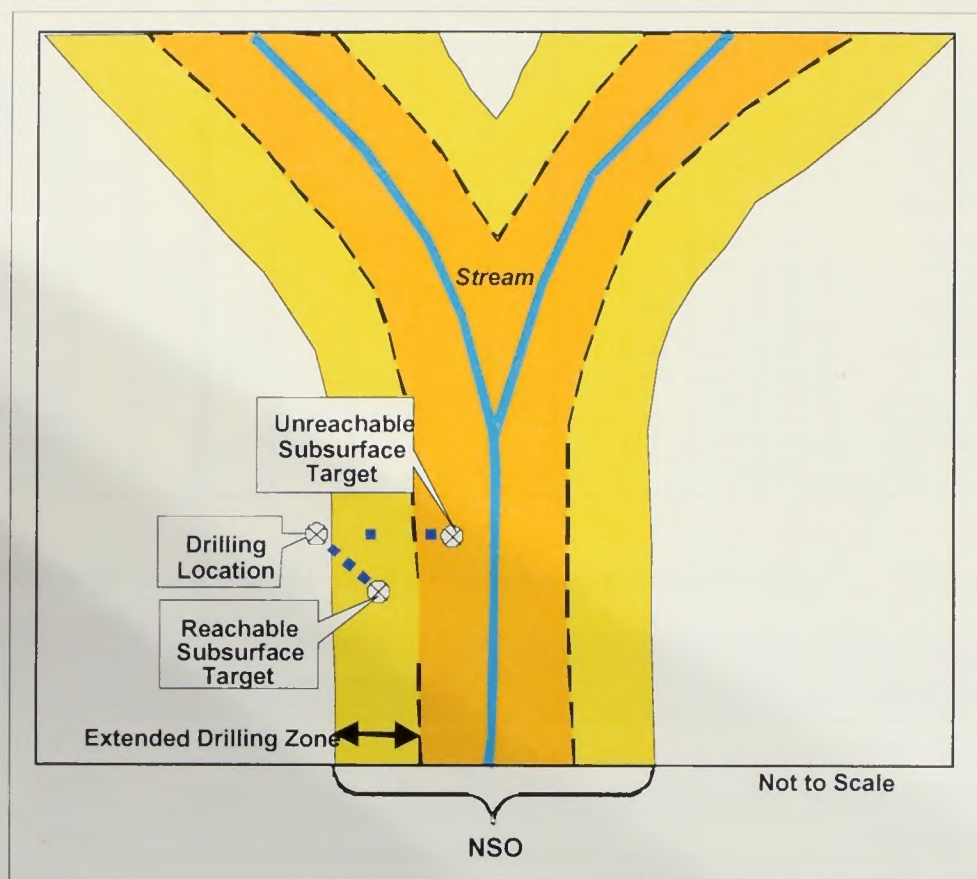
Stipulation	Exception Factor (EF)
Big Game	20%
Sage Grouse	20%
Raptors	30%
Big Game and Sage Grouse	4%
Big Game/Raptors	6%
Sage Grouse/Raptors	6%
Big Game, Sage Grouse and Raptors	1.2%

**Table A7-7 Exception Factors (GGR Study Area)**

### Treatment of NSO Areas

Directional drilling (or "extended drilling") is a technology that can be employed to reach subsurface targets not located directly underneath the drill site. Resources beyond a certain "extended drilling zone" (EDZ) are assumed not to be technically recoverable (Figure A7-2). While it is true that directional drilling horizontally out to distances of 5 or 6 miles is possible in production settings such as Alaska, this type of drilling is impractical for exploration in the Western basins.

Directional drilling for exploratory purposes occurs in Western basins, but it is much more limited in scope. As in the case of stipulation exceptions, BLM and USDA-FS field personnel were interviewed to determine the practicable width of the EDZ. The width of the EDZ is partially a function of the depth to the drilling objective—generally the deeper the objective, the larger the EDZ. The EDZ distances supplied by the offices and used in the EPCA inventory are shown in Table A7-8.



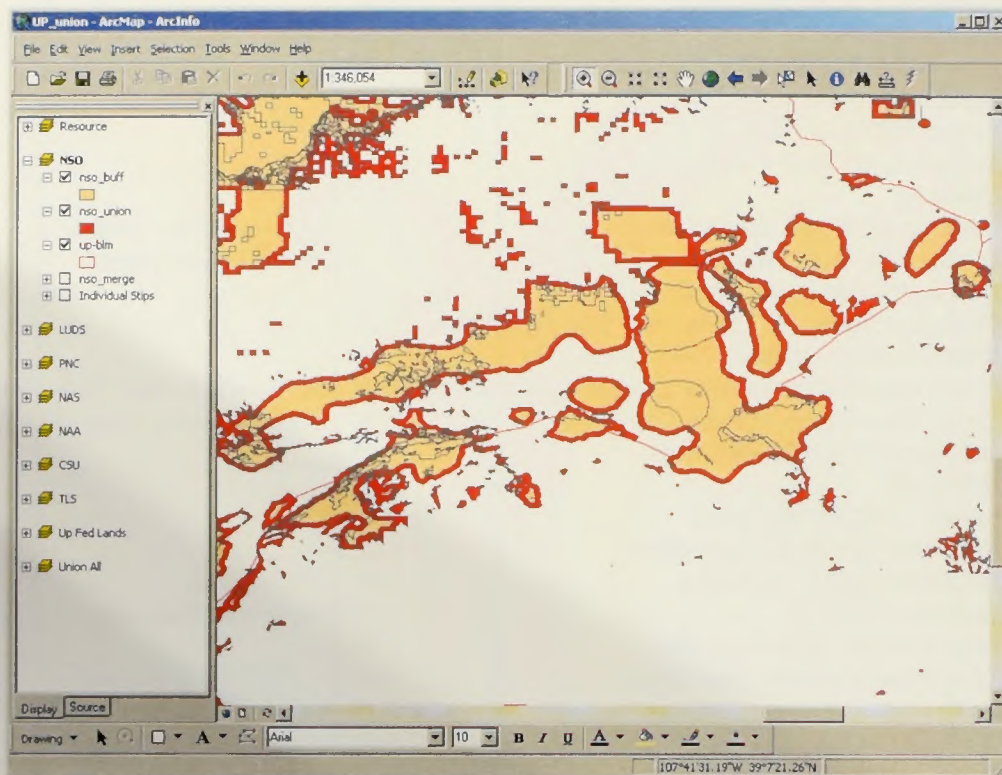
*Figure A7-2. Extended Drilling Zone*

The effect of the inclusion of the EDZs in the analysis was to remove an area of land from the perimeters of NSO polygons. The width of this area removed via GIS processing is determined by Federal jurisdiction (Table A7-8). The area removed then defaults to the access category that would otherwise apply in the absence of the NSO stipulation. The net effect is that the underlying resource is no longer considered inaccessible even though the surface above it cannot be occupied by drilling equipment.

Jurisdiction	EDZ (miles)	Comments
Albuquerque NM BLM Field Office	0.25	
Ashley NF	0.25	
Beavehead-Deerlodge NF	0.50	
Black Hills NF	0.25	
Buffalo WY BLM Field Office	0.25	
Buffalo Gap NG	0.13	
Butte MT BLM Field Office	0.25	
Carson NF	0.25	
Casper WY BLM Field Office	0.25	
Cedar City UT BLM Field Office	0.00	
Cibola NF	0.25	
Durango CO BLM Field Office	0.00	San Juan Basin portion
Durango CO BLM Field Office	0.50	Paradox Basin portion
Farmington NM BLM Field Office	0.25	
Glenwood Springs CO BLM Field Office	0.25	
Grand Junction CO BLM Field Office	0.25	
Grand Mesa /Uncompahgre /Gunnison NF	0.00	Paradox/San Juan Study Area
Grand Mesa /Uncompahgre /Gunnison NF	0.25	Uinta/Piceance Study Area
Gunnison CO BLM Field Office	0.25	
Helena NF	0.25	
Kanab UT BLM Field Office	0.00	
Kemmerer WY BLM Field Office	0.25	
Lander WY BLM Field Office	0.25	
Lewis and Clark NF	0.25	Eastern portions only
Lewistown MT BLM Field Office	0.25	
Little Snake CO BLM Field Office	0.25	
Manti La Sal NF	0.25	Paradox/San Juan Study Area
Manti La Sal NF	0.50	Uinta/Piceance Study Area
Miles City MT BLM Field Office	0.25	
Missoula MT BLM Field Office	0.50	
Moab UT BLM Field Office	0.25	
Monticello UT BLM Field Office	0.25	
New Castle WY BLM Field Office	0.00	
Oglala NG	0.13	
Pinedale WY BLM Field Office	0.25	
Price UT BLM Field Office	0.00	Paradox/San Juan Study Area
Price UT BLM Field Office	0.25	Uinta/Piceance Study Area
Rawlins WY BLM Field Office	0.25	
Richfield UT BLM Field Office	0.00	Paradox/San Juan Study Area
Richfield UT BLM Field Office	0.25	Uinta/Piceance Study Area
Rock Springs WY BLM Field Office	0.25	
Routt-Medicine Bow NF	0.25	
Salt Lake UT BLM Field Office	0.25	
Santa Fe NF	0.25	
South Dakota BLM Field Office	0.25	
St. George UT BLM Field Office	0.00	
Thunder Basin NG	0.25	
Uinta NF	0.25	
Uncompahgre CO BLM Field Office	0.50	Paradox/San Juan Study Area
Uncompahgre CO BLM Field Office	0.25	Uinta/Piceance Study Area
Vernal UT BLM Field Office	0.00	
White River CO BLM Field Office	0.25	
White River NF	0.25	

**Table A7-8 Extended Drilling Zones by Jurisdiction**

Figure A7-3 shows an example from the Uinta/Piceance Basin. Areas shown in red represent a 1/4-mile extended drilling zone removed from the NSO areas. Areas shown in beige represent the remaining NSO stipulations. Note that many small features are completely removed from the NSO theme by use of the EDZ. Similarly, linear NSO features less than 1/2 mile wide, such as trails, are removed as well.



*Figure A7-3 Removal of the Extended Drilling Zone from NSO Areas*

## Analytical Modeling of Federal Lands and Resources

The analytical goal of the EPCA inventory is to calculate the area of Federal lands (including non-Federal lands overlying federally owned oil and gas estate [split estate]) in each access category in the hierarchy and the volume of oil and gas resources underlying the Federal lands in each access category, while at the same time accounting for stipulation exceptions and the accessibility of the EDZ.

One of the primary goals for the development of the categorization was to achieve geographic independence for a given parcel of land subject to overlapping stipulations (hence, the use of the categorization hierarchy where that parcel of land would be subject to only one category). The following discussion illustrates the application of the land access categorization for an area of multiple stipulations from southern Wyoming near the Colorado state border (Greater Green River Study Area), where a raptor nest, sage grouse nest, and mule deer winter range define an access category. These types of stipulations are among the most common found in the study areas.

Figure A7-4 shows a selected point where the stipulations overlap and the resultant categorization is "Timing Limitation Stipulation (TLS) 6-9" according to the access categorization hierarchy. Figure A7-5 shows the land categorization before processing, but with the application of all stipulations in the area. Note that the core nest of the sage grouse stipulation (shown is blue), which cannot be occupied, is

considered "no surface occupancy" area (NSO). The remaining area is under various timing limitations (colored in shades of red) or under standard lease terms (in green).

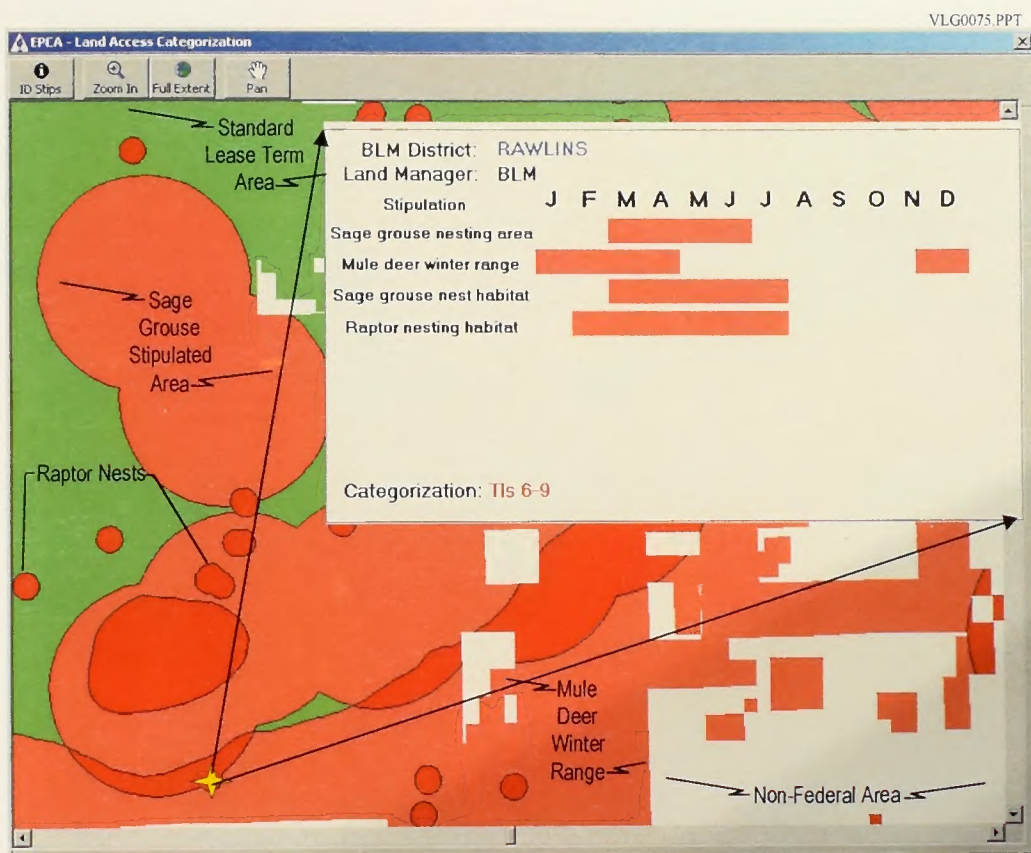


Figure A7-4 Display of Overlapping Timing Limitations (GGR Study Area)

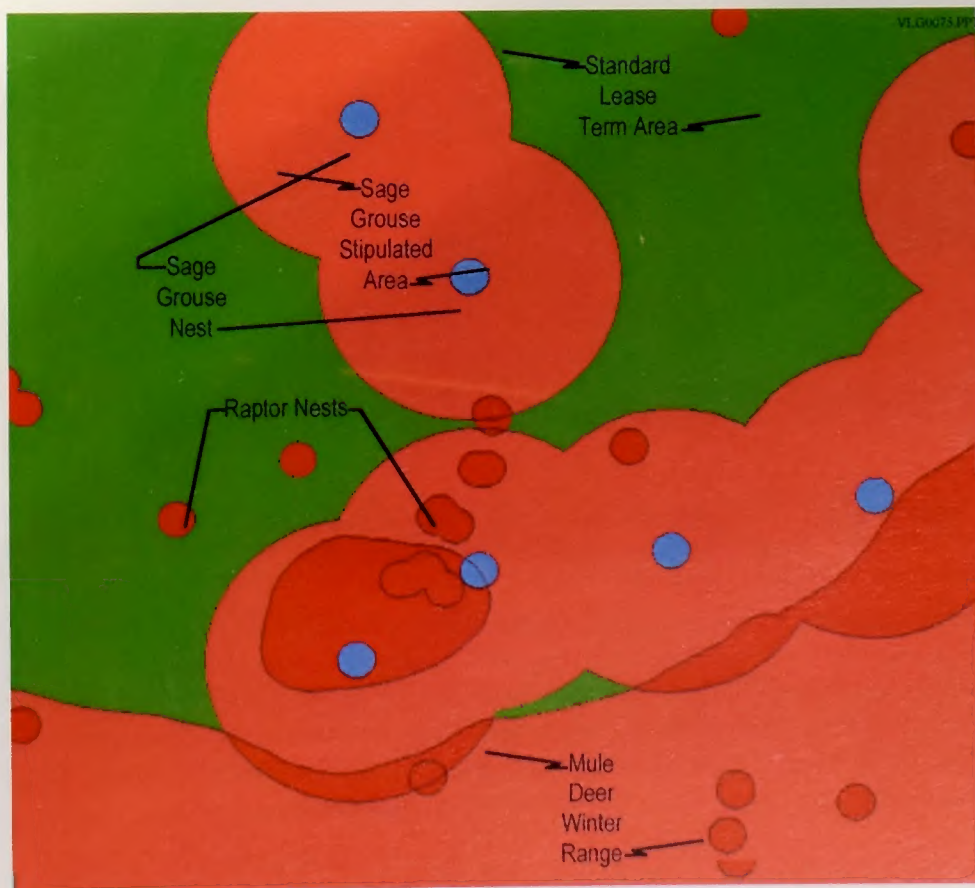
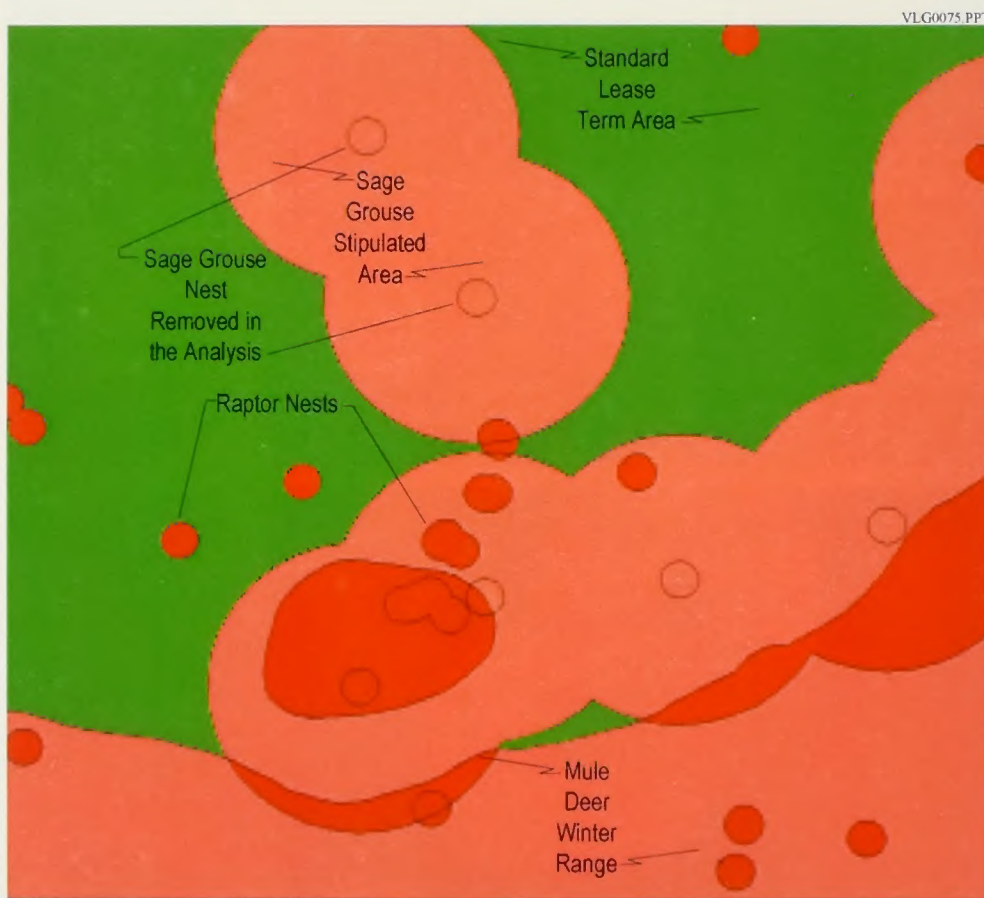


Figure A7-5 Display of Land Access Categorization (GGR Study Area)

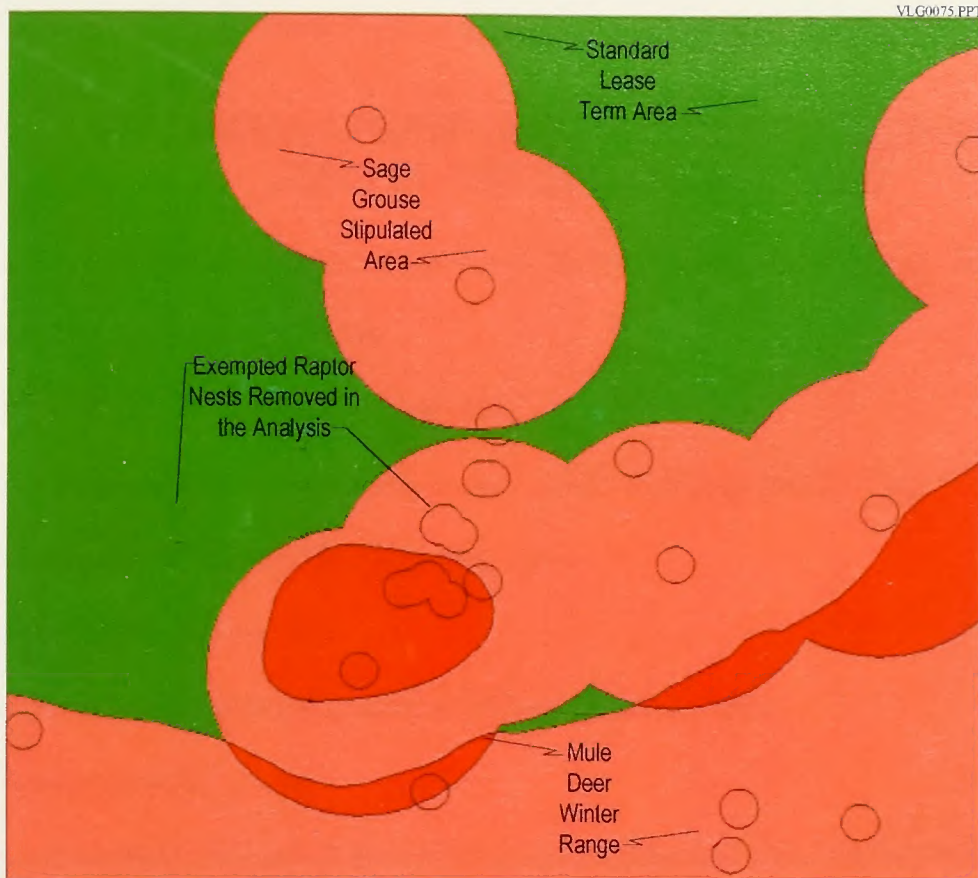
Next, Figure A7-6 shows the effect where the EDZ is applied to NSO areas. Note that use of the EDZ makes the sage grouse nest transparent to the categorization. Using a GIS-driven model developed for the project, all stipulations were similarly subjected to the categorization hierarchy and are presented in an interactive map, termed LACE (land access categorization, executable), accompanying this report.

Additionally, to account for stipulation exceptions in the analysis, the GIS-driven model determined the effects due to the presence or absence of the stipulations by selectively removing excepted stipulations in the computer. This is illustrated by Figure A7-7, which shows this for the example for the Greater Green River Study Area, where the raptor stipulation has been removed. Note that, in the absence of an excepted stipulation, the analysis defaults to the underlying stipulation or standard lease terms, as appropriate.



*Figure A7-6      Display of Land Access Categorization with Extended Drilling Zone Applied (GGR Study Area)*

If, for example, raptor stipulations are excepted 30 percent of the time, then, for an area represented by the raptor polygon (where raptor stipulations do not overlap other excepted stipulations), 30 percent from the contribution are represented by conditions where the raptor stipulation is not present and 70 percent ( $=1$  minus 30 percent) of the contribution comes from the conditions represented where the raptor stipulation is present. The total is calculated accordingly for all combinations of the exception factors within a given office jurisdiction (see Table A7-8) or where combinations of these exceptions exist (see Table:A7-9).



**Figure A7-7**      *Display of Land Access Categorization with Extended Drilling Zone Applied and with Raptor Stipulation Removed (GGR Study Area)*

Access categorization of the Federal lands and resources was determined in aggregate in the studies based upon discrete examination of individual GIS polygons using the following equation:

$$FLorRs = 3((1-EF) * FLorRs_{(EDZ)} + (EF * FLorRs_{(EDZ \text{ w/ Excepted})}))$$

Where

- FlorRs = Federal Lands or Resources
- EF = Exception Factor (e.g., see Table 7.4.1.3b)
- FLorRs<sub>(EDZ)</sub> = FLorRs determined using the Extended Drilling Zone
- FLorRs<sub>(EDZ w/ Excepted)</sub> = FLorRs determined using the EDZ plus removal of stipulations for which exceptions are granted

This equation allocates Federal lands and resources to access categories in the analysis based on use of the extended drilling zone and depending upon the presence or absence of excepted stipulations. As the excepted stipulations are removed to estimate Federal lands and resources, the model is set so as to default to the underlying stipulation category in the hierarchy.

This process results in the generation of hundreds of thousands of individual GIS polygons for the study areas, each with unique Federal lands and resources access characteristics. These data are then summed and reported by access category and Federal management agency. For oil and gas resources,

categorization is provided by specific resource type (Section 7.2.1).<sup>14</sup> By definition of their producibility, proved reserves are categorized as standard lease terms in the EPCA inventory.

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<sup>14</sup> An Excel spreadsheet showing the results for Federal lands and resources by BLM office jurisdiction for each study area in the EPCA inventory is provided on the CD-ROMs accompanying this report.

## APPENDIX 8

### LAND MANAGEMENT AND RESOURCE DOCUMENTS USED IN THE EPCA INVENTORY

Approved RMP for Public Lands Administered by the BLM Buffalo Field Office, 2000

Beaverhead National Forest EIS, 1996

Black Hills National Forest Land and RMP, 1991

Book Cliffs Proposed RMP/ Final Environmental Impact Statement (FEIS), 1984

Book Cliffs Record of Decision (ROD) & RPS, 1985

Bridger-Teton National Forest Plan

Bureau of Reclamation Special Stipulations, Billings Montana Office

Carson Nation Forest Plan, 1982

Cedar Beaver Garfield antimony Approved Resource Management Plan (ARMP)/ROD and RPS, 1986

Cibola National Forest Plan

Colorado State BLM Statewide Stipulations

Department of Energy Federal Lands Analysis Natural Gas Assessment, Southern Wyoming and Northwestern Colorado, 1999

Diamond Mtn Recreation Area (RA) ARMP/ROD, 1994

Diamond Mtn RA PRMP/FEIS, 1993

Farmington Oil and Gas Leasing Amendment, 1991

Final EIS for the Newcastle Resource Management Plan, 1999

Garnet RMP, 1986

Glenwood Springs Resource Area Plan Amendment, 1999

Grand Mesa/Uncompahgre/Gunnison National Forest Forest Plan, 1993

Grand Resource RMP, 1985

Grand Staircase Escalante National Monument Management Plan, 1999

**Appendix 8**  
**Land Management and Resource Documents**  
**Used in the EPCA Inventory**

Headwaters RMP, 1983

Helena National Forest Forest Plan, 1986

Henry Mt Management Framework Plan (MFP), 1982

Kemmerer RMP/ROD, 1986

Lewis & Clark National Forest Oil and Gas Leasing Final EIS, 1997

Lopez Project Utah State BLM Statewide Stipulations

Manti-La Sal Final EIS for Oil and Gas Leasing on Lands Administered by the Manti-La Sal National Forest, 1986

Manti-La Sal Final EIS for Oil and Gas Leasing on Lands Administered by the Manti-La Sal National Forest, 1986

Master Index of Utah BLM Land Use Plans & Amendments on CD, 2001

Miles City Oil and Gas Amendment, 1994

Miles City RMP, 1991

Montana State BLM Standard Stipulations

Northern Great Plains Final EIS

Paria Management Framework Plan, 1981

Parker Mountain MFP, 1982

Platte River RMP Revised & Updated Decisions, 2001

Rio Puerco RMP, 1992

ROD & Approved RMP for Public Lands Administered by the Newcastle Field Office, 2000

Routt National Forest Oil and Gas Leasing Analysis/FEIS, 1993

San Juan National Forest Forest Plan, 1983

San Juan RA ARMP/ROD, 1991

San Juan/San Miguel RMP 1991 Oil and Gas Amendment

San Rafael RA ARMP/ROD, 1991

Santa Fe National Forest Plan 1987, 1996 Amendment

Shoshone National Forest Final Oil and Gas Leasing EIS/ROD, 1992

St. George Office RMP, 1999

Vermillion Management Framework Plan, 1981

White River National Forest ROD

White River Resource Area RMP

Wyodak Coal Bed Methane Project final EIS, 2000

Wyodak drainage Coal Bed Methane EA, 2000

Wyoming St BLM Statewide Stipulations

Zion Management Framework Plan, 1981

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